Clinical Outcomes of DAMIS Traction Table-Assisted Anterior Approach versus Posterolateral Approach on Total Hip Arthroplasty in the Treatment of Femoral Head Necrosis

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AIM: Femoral head necrosis often leads to hip joint dysfunction, which can be effectively treated with total hip arthroplasty (THA). This study compares the clinical outcomes of direct anterior minimally invasive surgery (DAMIS) traction table-assisted anterior approach and the traditional posterolateral approach (PLA) on THA for femoral head necrosis.

METHODS: A total of 150 patients with femoral head necrosis, admitted between September 2019 and May 2022, were included in this study. In this sample, 68 patients underwent THA via the PLA (control group), while the remaining 82 patients were treated with THA using the DAMIS traction table-assisted anterior approach (observation group). The surgical-related indicators, postoperative pain scores, Harris hip scores (HHS), and rates of complication incidence between the two groups were compared.

RESULTS: There were no significant differences in surgery time between the two groups (p = 0.054). The observation group had significantly less intraoperative blood loss (p = 0.018), shorter incision length (p = 0.001), and significantly shorter time elapsed to first out-of-bed activity (p = 0.016) and shorter hospital stay compared to the control group (p = 0.001). The postoperative pain scores in the observation group were significantly lower than in the control group (p = 0.001), and the HHS at 2 weeks and 4 weeks after surgery were significantly higher in the observation group (p < 0.05). The overall complication rate in the observation group was significantly lower than in the control group (p = 0.011).

CONCLUSIONS: DAMIS traction table-assisted anterior approach for THA demonstrates clinical advantages in the treatment of femoral head necrosis, effectively accelerating postoperative recovery and reducing the occurrence of complications.

Keywords: DAMIS traction table; direct anterior approach; posterolateral approach; femoral head necrosis; total hip arthroplasty

Introduction

Total hip arthroplasty (THA) is primarily used for treating hip joint diseases such as femoral head necrosis, hip fractures, and rheumatoid arthritis [1,2]. Significant advancements have been achieved in various aspects of THA techniques, including materials compatibility, surgical precision, and prosthesis design, which have greatly increased success rates in surgeries and reduced postoperative complications [3]. However, complications such as infection, hip prosthesis dislocation, and fracture still persist, requiring continued attention and effective prevention.

Both efficacy and safety of treatment are dictated by the surgical approach selected, which is linked to the extent of soft tissue damage, the operative field visibility, and the post-

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operative recovery process. Therefore, selecting the appropriate surgical approach based on the distinctive anatomical features of individual patients is critical for optimizing surgical outcomes and minimizing complications [4]. The posterolateral approach (PLA) is a conventional, widely used method by virtue of its clear exposure of the hip joint structures and its relative ease of operation. However, it involves cutting through the posterior hip muscles, potentially increasing the risk of dislocation and delayed recovery [5]. In contrast, the direct anterior approach (DAA) is a minimally invasive technique that enters the hip joint through the intermuscular spaces, causing less damage to surrounding soft tissues, thus reducing postoperative pain and speeding up recovery [6]. However, this approach, being technically more complex, thus requires surgeons with more surgical experiences and specialized instruments, and visibility of operative view in obese or muscular patients is particularly challenging with this technique [7].

To address the limitations of traditional approaches, we introduced the direct anterior minimally invasive surgery (DAMIS) traction table-assisted anterior approach into clinical practice. Building on the DAA, the DAMIS technique is an optimized approach developed through detailed

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anatomical study and refinement of surgical instruments. This modified approach retains the advantages of the DAA, i.e., avoiding muscle dissection and reducing soft tissue trauma [8]. Additionally, by allowing adjustments of limb positioning and angles through the DAMIS traction table, it offers improved surgical visibility and operational convenience, facilitating optimal exposure of the acetabulum and femoral head. Nevertheless, while this method demonstrates potential advantages in clinical practice, existing research remains limited, and further studies are required to verify its specific efficacy across diverse patient populations. Therefore, this study aimed to compare the clinical outcomes of DAMIS traction table-assisted anterior approach and conventional PLA in patients undergoing THA due to femoral head necrosis. The findings are intended to provide a critical basis for optimizing approach selection in THA and to support the broader clinical application of the DAMIS traction table-assisted technique.

Materials and Methods

Patients

This study included 150 patients with femoral head necrosis who underwent THA at the First People's Hospital of Longnan, Longnan, China, between September 2019 and May 2022. Based on the surgical approach, patients were divided into two groups: the control group (68 cases, undergoing traditional PLA) and the observation group (82 cases, undergoing DAMIS traction table-assisted anterior approach). Informed consent was obtained from all patients and their families, and the study was approved by the Medical Ethics Committee of the First People's Hospital of Longnan (Approval No. LNKY-2022-16). The study was conducted in compliance with the principles of the Declaration of Helsinki.

The inclusion criteria are as follow: (1) Individuals aged 45 years and older; (2) meeting the diagnostic criteria for femoral head necrosis as recommended by expert guidelines [9]; (3) without other orthopedic diseases; (4) without cognitive dysfunction and mental history; and (5) without severe walking impairment prior to surgery. Individuals with the following conditions were excluded from this study: (1) history of coagulation dysfunction; (2) presence of severe infectious diseases that are difficult to control before surgery; (3) presence of immune system diseases; (4) history of previous THA; (5) comorbid with severe cardiovascular and cerebrovascular diseases; (6) overweight and having excessive abdominal fat; and (7) moderate to severe hip dysplasia.

Traditional Posterolateral Approach in Control Group

Intravenous antibiotics were administered 20 minutes before the THA, and continuous epidural anesthesia was used. The patient was positioned in the lateral decubitus position, with the pelvis fixed anteriorly and posteriorly, and the lower limbs were disinfected. The surgical incision was ap-

proximately 8 cm in length and made at a slight angle, with 65% of the incision located distally to the apex of the greater trochanter and 35% proximally, using the greater trochanter as a landmark. After making the incision, the hip joint was exposed layer by layer, with particular care taken to avoid injury to the sciatic nerve during the procedure. The lesser trochanter was revealed via posterior hip joint dislocation after hip joint exposure. An osteotomy was carried out between the greater trochanter's apex and a position 1-1.5 cm above the lesser trochanter to remove the necrotic femoral head. After removal, the acetabulum was fully exposed using a retractor. It was reduced in size with a rasp to a size 2 mm smaller than the acetabulum specified before the procedure. The lining of the acetabular trial mold was installed after positioning the acetabulum at a 0° angle. After installation, a retractor was used to lift the proximal femur. The proximal incision was protected during operation. To create the proximal femoral medullary cavity on the medial side of the greater trochanter, a box-shaped osteotome was used. The cavity was expanded and fixed, and the hip joint reduction operation was performed after the specimen's femoral head was implanted. After the trial operation, the acetabular lining was inserted if the lower limb length, femoral range of motion and offset, and joint stability tests presented no issues. The femoral stem prosthesis were inserted, followed by the femoral head. The lower leg length, femoral range of motion and offset and joint stability were measured. In the event of no complications, absorbing sutures were used to protect the external rotator suture and the hip joint capsular flap to the greater trochanter. The surgical incision was sutured eventually.

Direct Anterior Minimally Invasive Surgery Traction Table-Assisted Anterior Approach in Observation Group

Intravenous antibiotics were administered 20 minutes before the procedure, followed by continuous epidural anesthesia. After anesthesia, the lower limbs were disinfected, and the patient took a supine position for pelvic fixation. After fixation, the incision was made, extending downward to 2 cm outside and below the anterior superior iliac spine on the affected side. The incision length is typically 7 to 10 cm, and it should be kept parallel to the line joining the anterior superior iliac spine and the fibular head (Fig. 1A-C). After positioning the incision, the sheath on the surface of the tensor fascia lata was incised along the incision line, and blunt dissection was used to separate the front edge of the tensor fascia lata within the sheath. The gap between the sartorius muscle and the tensor fascia lata was separated (Fig. 1D). After separating the branch of the patient's lateral circumflex femoral artery, the artery was ligated, and the patient's joint capsule was exposed. A retractor was placed on the outside of the patient's joint capsule above and below the femoral neck. Subsequently, the fascia and fat tissue on the surface of the joint capsule was cleaned, and the patient's joint capsule cut in a "V" shape (Fig. 1E). The



Fig. 1. Equipment used and incisions made during the surgery via direct anterior minimally invasive surgery (DAMIS) traction table-assisted anterior approach. (A) Traction table for lower limb. (B) incision site marking. (C) incision length. (D) dissection of the lateral circumflex femoral artery branches. The red arrow indicates the anatomical boundary between the tensor fascia lata and the sartorius-rectus femoris muscles, as well as the direction of the blunt dissection plane. (E) "V"-shaped capsular incision. Note: The images in panels (B,C) were obtained with the informed consent of a patient. Panel (D) is a schematic created using BioRender software (https://www.biorender.com/, BioRender Inc., Toronto, ON, Canada).

intersection of the greater trochanter and the lateral femoral neck, as well as maintaining the integrity of the joint capsule flap, to ensure clear visualization of the hip joint structures and provide support for joint stability.

After the femoral neck was exposed, the patient's lower limbs were gently pulled to maintain tension on the femoral head and neck. Osteotomy was then carried out at 1-1.5 cm above the lesser trochanter. The affected limb was lowered and externally rotated by 45° under traction. The femoral head was removed, and the posteromedial joint capsule was freed until the lesser trochanter was exposed. To further expose the acetabulum, the osteophyte was removed, and the damaged labrum due to overuse was treated. A "door"shaped retractor was used to pull the patient's rectus femoris muscle and joint capsule valve to both sides (Fig. 2). The acetabulum was reamed to the correct size using an acetabular reamer. An acetabular prosthesis was installed so that the mounting handle was horizontal and 45° abducted, and the position of the acetabular prosthesis was determined with the help of the C-arm, and then the inner liner was placed, with the high side of the inner liner on the upper front.

The femoral end of the patient was treated with the use of the DAMIS traction table. First, the affected limb was externally rotated by 120°–140°, followed by hyperextension and adduction (Fig. 3). The proximal femur of the affected limb was then thoroughly exposed using equipment such as bone lifting hook and bone prying tool, followed by an eccentric opener to open the mouth and an eccentric reamer to ream the marrow several times. Under C-arm fluoroscopy, the length of the lower limbs and the compatibility of the prosthesis were examined. After the trial model and the length of the neck had been chosen, the prosthesis was reset. The C-arm fluoroscopy was employed to validate whether the prosthesis had been successfully installed based on patient's skeletal structure. Depending on the circumstances, the drainage tube was installed selectively, the surgical instruments were removed, and the incision was sutured layer by layer.

Observation Indicators

Surgery-Related Indicators

In both groups of patients, the time from anesthesia to incision suturing was recorded, intraoperative blood loss was measured by weighing the gauze (Blood loss = Weight of blood-soaked gauze – Weight of original gauze), and the patient's incision length was measured along the long axis of the body with a wound measuring ruler, all while recording the time elapsed leading to first out-of-bed activity and the length of hospital stay.

Postoperative Pain

The visual analog scale (VAS) was used as the evaluation tool, with scores ranging from 0 to 10. "0" points represent no pain, whereas "10" points indicates agony. A higher score denotes more extreme pain [10].

Harris Hip Scores

Harris hip scores (HHS) were evaluated at 1 week, 2 weeks and 4 weeks after surgery. This quantitative instrument covers four dimensions: pain, function, deformity, and range of motion. With a total score of 100 points, <70 Chang-feng Liu, et al.



Fig. 2. "Door"-shaped retractor. Note: The image was obtained with the informed consent of the patient.

points indicate the presence of functional impairment, with higher scores indicating better hip function. The scoring was performed by two orthopedic surgeons who were blinded to the procedure performed [11].

Complication Rates

Complications such as prosthetic dislocation, postoperative infection, deep vein thrombosis, periprosthetic femoral fracture, and lateral femoral cutaneous nerve injury, were recorded for both groups of patients at a follow-up session one month post-surgery. The incidence rate of these complications was calculated.

Statistical Analysis

Statistical analysis was performed using SPSS version 20.0 (IBM, New York, NY, USA). Quantitative data are presented as mean \pm standard deviation (SD). Data normality was assessed using the Shapiro–Wilk test. For normally distributed data, intergroup comparisons were performed using the independent *t*-test. For comparisons in-

volving three or more groups, one-way analysis of variance (ANOVA) was used, followed by Tukey's honest significant difference (HSD) post-hoc test. Qualitative data are presented as frequencies, and intergroup comparisons were conducted using the chi-square test or Fisher's exact test. For cases with a small sample size or insufficient expected frequencies, the chi-square test correction formula was applied. A *p*-value less than 0.05 was considered statistically significant.

Results

Comparison of General Information

A total of 150 patients were included in this study, with 68 in the control group and 82 in the observation group. The average age of the patients in the control group and observation group was 62.41 ± 15.82 years and 63.97 ± 16.01 years, respectively. A comparison of the gender, age, and necrosis site of the patients in both groups revealed no significant differences (p > 0.05) (Table 1).



Fig. 3. Operation principle of the DAMIS traction table-assisted anterior approach. (A) Relaxed traction to release the posterior joint capsule of the femur. (B) Externally rotate the affected limb 45° around the knee joint axis. (C) Hyperextension and relaxed traction for femoral handling. (D) Lower and adduct the traction table to expose the femoral head. Note: The figure was redrawn and modified based on the product manual publicly available on the official website (http://www.clzd.com/), and created using CorelDRAW x7 (Corel Corporation, Ottawa, ON, Canada).

Comparison of Surgery-Related Indicators and Postoperative Pain

The surgery duration was comparable in the control and observation groups (p = 0.054). Our analysis showed that intraoperative blood loss was lower in the observation group than in the control group (p = 0.018); and the length of incision (p = 0.001), the time elapsed leading to first out-ofbed activity (p = 0.016), and the length of hospital stay (p = 0.001) were all shorter in the observation group than in the control group. The postoperative pain score was significantly lower than the control group (p = 0.001) (Table 2).

Comparison of the Harris Hip Scores at 1 Week, 2 Weeks and 4 Weeks after Surgery

The comparison found that there was no significant difference in the HHS between the control and observation groups at 1 week after surgery (p = 0.851). However, at 2 weeks and 4 weeks after surgery, the HHS of the observation group was significantly higher than that of the control group (p < 0.001 and p = 0.038, respectively). Furthermore, it was observed that the HHS in both groups increased significantly over time (p < 0.001) (Table 3).

Comparison of Incidence Rates of Postoperative Complications

There was no statistically significant difference in the incidence of prosthetic dislocation, postoperative infection, deep vein thrombosis, periprosthetic femoral fracture, or lateral femoral cutaneous nerve injury between the two groups (p > 0.05). It is worth noting that, nevertheless, the total incidence of these complications in the observation group was lower than that in the control group (p = 0.011) (Table 4).

Discussion

This study aimed to compare the clinical outcomes of DAMIS traction table-assisted anterior approach and traditional PLA in THA in patients with femoral head necrosis. Our retrospective analysis of surgery-related indicators, postoperative pain scores, HHS, and complication rates in 150 patients showed that the DAMIS traction tableassisted anterior approach significantly reduced intraoperative blood loss, incision length, postoperative pain scores, length of hospital stay, and incidence of complications, as compared to the traditional PLA approach. Additionally, the observation group had significantly higher HHS at 2 and 4 weeks postoperatively compared to the control group.

Index	Control group $(n = 68)$	Observation group $(n = 82)$	χ^2/T	р
Gender			0.655	0.418
Male	45 (66.18)	49 (59.76)		
Female	23 (33.82)	33 (40.24)		
Age (years)	62.41 ± 15.82	63.97 ± 16.01	0.597	0.551
Necrotic site			0.190	0.909
Left side	24 (35.29)	30 (36.59)		
Right Side	28 (41.18)	31 (37.80)		
Bilateral	16 (23.53)	21 (25.61)		

Table 1.	Comparison	of general	information	between the	control and	observation groups.
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Table 2.	Comparison (of surgery-related	l indicators and r	postoperative i	pain between t	the control and	observation groups.

Group	Number of cases	Surgery duration (min)	Intraoperative blood loss (mL)	Incision length (cm)	Time elapsed to first out-of-bed activity (h)	Length of hospital stay (days)	Postoperative pain (points)
Control group	68	113.74 ± 22.85	368.15 ± 124.71	8.04 ± 1.54	20.64 ± 4.29	16.34 ± 2.48	3.25 ± 0.43
Observation group	82	106.34 ± 23.57	319.28 ± 123.58	7.39 ± 0.62	18.67 ± 5.42	15.17 ± 1.56	3.02 ± 0.38
Т	-	1.941	2.401	3.497	2.431	3.516	3.476
р	-	0.054	0.018	0.001	0.016	0.001	0.001

Table 3.	Comparison	of the Harris	nip scores between	the control and	observation grou	ps at different time	points.

Group	Number	1 week after 2 weeks after		4 weeks after	F	п	
Group	of cases	surgery	surgery	surgery	1	P	
Control group	68	68.84 ± 5.49	$75.02\pm3.46^*$	$84.29 \pm 6.18^{*^{\#}}$	153.6	< 0.001	
Observational group	82	69.01 ± 5.52	$78.95\pm2.17*$	$86.27 \pm 5.39^{*\#}$	287.4	< 0.001	
Т	-	0.188	8.473	2.095			
<i>p</i>	-	0.851	< 0.001	0.038			

* p < 0.001 compared to 1 week after surgery; [#] p < 0.001 compared to 2 weeks after surgery.

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Group	Number	Prosthetic	Postoperative	Deep vein	Periprosthetic	Lateral femoral cutaneous	Total
	of cases	dislocation	infection	thrombosis	femoral fracture	nerve injury	incidence
Control group	68	3 (4.41)	2 (2.94)	2 (2.94)	2 (2.94)	3 (4.41)	12 (17.65)
Observation group	82	0 (0.00)	2 (2.44)	1 (1.22)	0 (0.00)	1 (1.22)	4 (4.88)
χ^2	-	-	0.000	0.027	-	0.483	6.361
p	-	0.091	1.000	0.870	0.204	0.485	0.011

Table 4. Comparison of postoperative complications between the two groups (n (%)).

The DAMIS traction table-assisted anterior approach is an innovative minimally invasive technique that utilizes a traction table to adjust the position and angle of the lower limbs. Compared to the traditional PLA, this method enhances the surgical field of view while minimizing muscle resection and reducing damage to the surrounding soft tissues [12,13]. A systematic review and meta-analysis by Ramadanov *et al.* [12] revealed that the traction table-assisted DAA resulted in greater intraoperative blood loss but was associated with a lower incidence of periprosthetic fractures compared to the non-traction table-assisted DAA. However, it should be noted that the related studies are limited, and further research is needed to explore and confirm the long-term effects of such techniques.

In our study, the DAMIS traction table-assisted DAA is developed on the basis of anatomical research and improvements in surgical instruments, optimizing and enhancing the traditional DAA approach. Although there was no significant difference in the surgery duration between the two groups investigated in the present study, we found that the pain scores of the observation group, assessed with the VAS, were significantly lower than those of the control group. Furthermore, at 2 and 4 weeks postoperatively, the HHS in the observation group were significantly higher than those in the PLA group. These findings suggest that the DAMIS traction table-assisted anterior approach effectively alleviates postoperative discomfort, improves hip joint function, enhances postoperative quality of life, and promotes recovery.

THA is a common surgical procedure that can significantly improve hip joint function and quality of life [14]. However, postoperative complications remain a critical factor affecting recovery and patient prognosis. It has been reported that patients treated with THA via the posterolat-

eral approach are at a higher risk of nerve injuries (such as lateral femoral cutaneous nerve injury) and hip dislocation [15], leading to a higher complication rate. These risk factors may delay postoperative recovery, exacerbate patient discomfort, and impact the safety and efficacy of the treatment [16,17]. In terms of complication rates, our study showed that the overall complication rate in the observation group was significantly lower than that in the control group. The incidence of periprosthetic femoral fractures and lateral femoral cutaneous nerve injuries was lower in the observation group. This difference may be attributed to the varying impacts of the two surgical approaches on soft tissue and nerve structures [18,19]. Notably, although the DAMIS traction table-assisted anterior approach shows potential advantages in reducing blood loss and lowering complication rates, it requires higher technical expertise and more precise instrumentation during the procedure. Therefore, it is advised that this technique should only be adopted by surgeons who have been adequately trained and have vast experience.

While this study provides valuable clinical comparative data, certain limitations should be acknowledged. First, the small sample size restricts the broader applicability of the findings. Future research should involve larger-sample, multicenter, prospective studies to enhance generalizability of the findings obtained. Second, baseline data were relatively insufficient, and future studies should prioritize collecting more comprehensive baseline information to improve the accuracy and completeness of the findings. Additionally, the follow-up period was limited to only one month postoperatively, limiting insights into long-term clinical outcomes and potential complications. Finally, due to technical and equipment constraints, we were unable to assess subtle differences in prosthesis length in real time during surgery. Such variations may impact the long-term stability of the prosthesis, and future studies should consider integrating more precise intraoperative measurement tools.

Conclusions

This study compared the clinical outcomes of DAMIS traction table-assisted anterior approach with the traditional PLA in patients treated with THA. The DAMIS traction table-assisted anterior approach can significantly reduce intraoperative blood loss, shorten hospital stay, and promote postoperative functional recovery, while improving postoperative pain scores and HHS in patients. Therefore, this minimally invasive approach holds the potential as a treatment option for femoral head necrosis treated with THA.

Availability of Data and Materials

The data used to support the findings of this study are available from the corresponding author upon request.

Author Contributions

Conceptualization: ML, YZ and CL; Methodology: ML and CL; Formal Analysis: YZ, YJ, LW and XM; Data curation: ML, JZ, MD, HH and JD; Writing - Original Draft: ML and YZ; Writing - Review and Editing: ML, YZ and CL; Project administration: ML; Investigation: YZ; Supervision: CL; Validation: CL. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was approved by the Medical Ethics Committee of the First People's Hospital of Longnan (Approval No. LNKY-2022-16) and adhered to the principles of the Declaration of Helsinki. Informed consent was obtained from the patients and their families.

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Conflict of Interest

The authors declare no conflict of interest.

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