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Clinical and radiological outcomes of direct anterior versus posterolateral total hip arthroplasty in ankylosing spondylitis: A propensity-matched study

Xingshan Wang, MD[1#], Shaoyi Guo, MD[1#], Dazhao Chen, MD[1], Yixin Zhou, MD[1], Tao Bian, MD[1], Siliang Man, MD[2], Liang Zhang, MD[1]

[1]Department of Orthopaedic Surgery, Beijing Jishuitan Hospital, Capital Medical University, Beijing, China
[2]Department of Rheumatology and Immunology, Beijing Jishuitan Hospital, Capital Medical University, Beijing, China

ABSTRACT

Objectives: This study aims to compare the clinical and radiological outcomes of the direct anterior approach (DAA) and the traditional posterior-lateral approach (PLA) for total hip arthroplasty (THA) in patients with ankylosing spondylitis (AS).

Patients and methods: Between July 2001 and May 2024, a total of 137 patients (117 males, 20 females; mean age: 40.21±13.28 years; range, 17 to 73 years) with AS who underwent THA using the DAA or PLA were retrospectively analyzed. Using propensity score-matching, we retrospectively analyzed data on 164 hips with AS for which THA was performed, with 41 and 123 hips in the DAA and PLA groups, respectively. Preoperative baseline characteristics, surgical data, clinical and radiological outcomes at follow-up were collected and compared between the two groups.

Results: The mean follow-up was 68.05±38.09 months. There were no significant intergroup differences in terms of surgical data, postoperative complications, clinical scores, or patient satisfaction ($p > 0.05$). Compared to the PLA group, the DAA group had a significantly higher rate of achieving hip flexion over 90° (82.93% *vs*. 60.98%, $p = 0.010$), with fewer patients in the group reporting difficulty with putting on socks ($p = 0.003$). The DAA group exhibited a smaller acetabular anteversion (17.10±6.60° *vs*. 20.68±8.73°, $p = 0.031$), with a higher proportion of acetabular components positioned within the Lewinnek safe zone (82.93% *vs*. 60.16%, $p = 0.008$).

Conclusion: Although both surgical approaches are effective for managing hip involvement in ankylosing spondylitis undergoing THA, the DAA may offer functional benefits and improved prosthetic alignment. These advantages support its consideration as a favorable surgical option in appropriately selected patients,

Keywords: Ankylosing, arthroplasty, articular, hip, range of motion, replacement, spondylitis, treatment outcome.

Ankylosing spondylitis (AS) is a chronic inflammatory disease primarily affecting the spine and sacroiliac joints, leading to stiffness, pain, and reduced mobility.[1] Total hip arthroplasty (THA) is often required for AS patients with hip involvement, aiming to restore function and improve quality of life.[2] However, due to the unique challenges presented by AS, including spinal rigidity, altered pelvic alignment, complex intraoperative procedure, and limited hip range of motion (ROM), the surgical technique chosen for THA plays a crucial role in postoperative outcomes.[3-5] Previous studies have reported poor postoperative hip flexion function

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Correspondence: Liang Zhang, MD. Department of Orthopaedic Surgery, Beijing Jishuitan Hospital, Capital Medical University, 31 Xinjiekou East Street, Xicheng District, 100035 Beijing, China.

E-mail: lancetzll@aliyun.com

Correspondence: Siliang Man, MD. Department of Rheumatology and Immunology, Beijing Jishuitan Hospital, Capital Medical University, 31 Xinjiekou East Street, Xicheng District, 100035 Beijing, China.

E-mail: m13701380579@163.com

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≠ Xingshan Wang and Shaoyi Guo contributed equally to this manuscript and should be considered co-first authors

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in patients with AS, leading to difficulties in daily activities and adversely affecting patient satisfaction.[6] In recent years, the direct anterior approach (DAA) has gained widespread attention due to its advantages, including minimal surgical trauma, faster postoperative recovery, and favorable short-term outcomes.[7] A few studies have applied the DAA approach to THA in patients with AS; however, the follow-up periods have usually been short.[8,9]

Patients with AS often present with abnormal hip anatomy, which poses challenges for THA. Direct anterior approach may facilitate early functional recovery and more accurate acetabular cup placement, but long-term outcomes and improvements in hip ROM in AS remain unclear. In the present study, we hypothesized that DAA would provide superior hip flexion, functional recovery, and implant positioning compared to PLA in patients with AS undergoing THA. We, therefore, aimed to compare the clinical and radiological outcomes of the DAA and the traditional posterior-lateral approach (PLA) for THA in patients with AS.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Beijing Jishuitan Hospital, Capital Medical University, Department of Orthopaedic Surgery between July 2001 and May 2024. The medical records of patients with AS who underwent THA at our institution were screened. Total hip arthroplasty was indicated for patients with severe hip involvement and for those whose symptoms and functional impairment could not be effectively managed with conservative treatments. Patients who were diagnosed with AS and met the modified New York criteria (1984) and those who underwent THA and had complete medical records were included. Exclusion criteria were as follows: loss to follow-up for any reason; use of a surgical approach other than the DAA or PLA; a history of infection or previous surgery on the affected hip; and preoperative

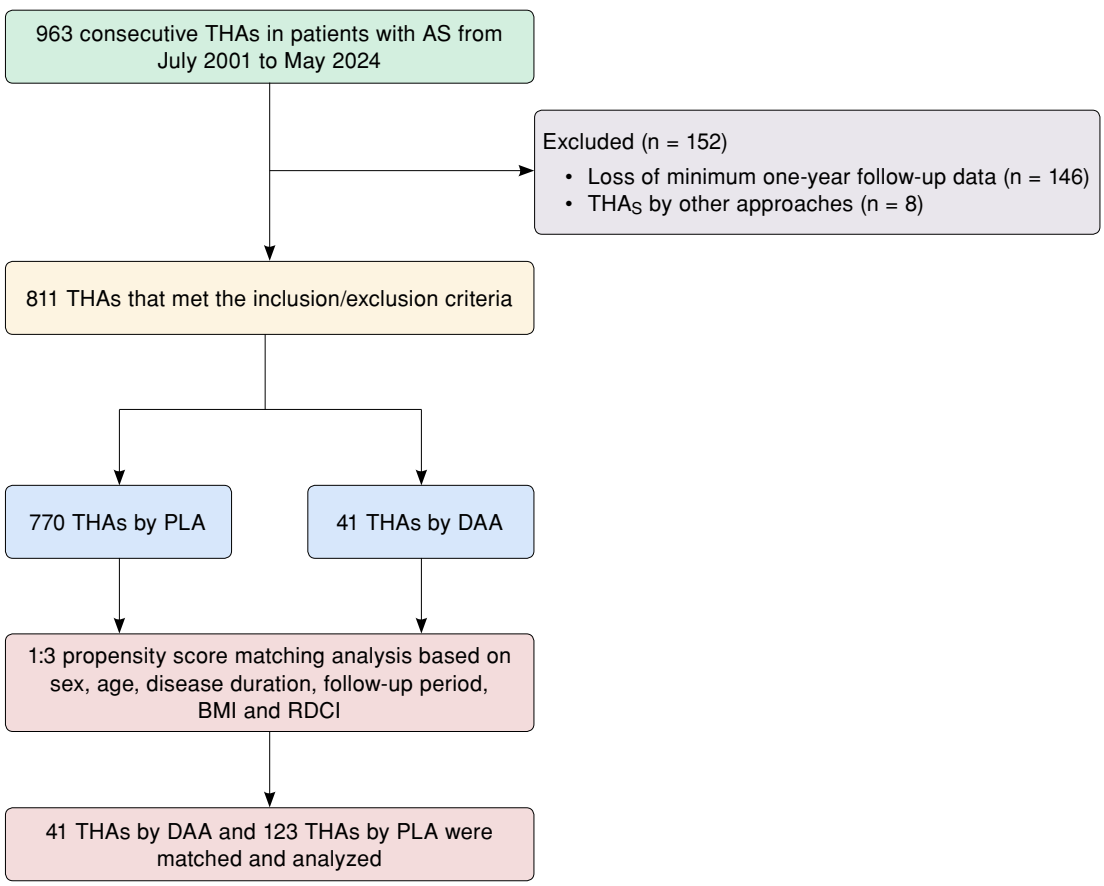

FIGURE 1. Patient selection flow chart.

THA, total hip arthroplasty; AS, Ankylosing spondylitis; PLA, posterolateral approach; DAA, direct anterior approach; BMI, body mass index; RDCI, rheumatic disease comorbidity index.

comorbidities, such as other musculoskeletal or neurological disorders that could potentially have affected the postoperative functional assessments. A complete-case analysis was conducted, and patients with missing clinical or radiographic data were excluded from the study. During the study period, a total of 963 THAs were performed in patients with AS. The study included a total of 137 patients (117 males, 20 females; mean age: 40.21±13.28 years; range, 17 to 73 years). The study flowchart is shown in Figure 1. A written informed consent was obtained from each patient. The study protocol was approved by the Beijing Jishuitan Hospiptal Ethics Committee (Date: 06.04.2020, No: 202004-83). The study was conducted in accordance with the principles of the Declaration of Helsinki.

The patients were classified according to the surgical approach and underwent further propensity score-matching. The propensity score was constructed using a multiple logistic regression model that included the following demographic covariates: sex, age, disease duration, follow-up period, body mass index (BMI) and the rheumatic disease comorbidity index. The study group (DAA) was matched 1:3 with the control group (PLA) based on the propensity score using the nearest-neighbor method, with a standard caliper width of 0.2.

The surgeries were performed by a team of experienced surgeons at our institution. All procedures were performed after the surgeons surpassed the learning curve for the corresponding surgical approaches. The surgical approach was determined preoperatively through a shared decision-making process, based on both patient and surgeon preference. All patients received standardized perioperative management and postoperative rehabilitation guidance. Baseline data, surgical information, and follow-up records were retrieved from the medical records system.

Baseline and surgical data

Preoperative baseline data included the patients' medical history, physical examination, and relevant laboratory tests. Patients were asked about comorbidities including cardiovascular and cerebrovascular diseases, respiratory disorders, malignancies, diabetes, and depression. The physical examination data included the ROM of the hip joint, Thomas sign, and angle of hip flexion contracture deformity. Radiography of the hip joint was also performed to assess the affected side and bony fusion. Additionally, preoperative erythrocyte sedimentation rate (ESR) and levels of C-reactive

TABLE I
Demographics of the study population

	Unmatched				Matched			
	PLA (n = 770)	DAA (n = 41)	*p*	SMD	PLA (n = 123)	DAA (n = 41)	*p*	SMD
Age (year), (mean±SD)	40.21±13.37	40.17±11.70	0.983	0.003	40.11±12.84	40.17±11.70	0.980	−0.004
Sex, n (%)								
Male	670 (87.01)	32 (78.05)	0.101	0.267	102 (82.93)	32 (78.05)	0.484	0.130
Disease duration (year), (mean±SD)	20.18±10.96	19.98±10.47	0.906	0.019	19.96±10.15	19.98±10.47	0.993	−0.002
Follow-up period (mo), (mean±SD)	122.69±63.94	70.02±24.37	<0.001	0.824	67.39±41.74	70.02±24.37	0.624	−0.063
BMI (kg/m^2), (mean±SD)	23.07±4.67	23.76±3.70	0.351	−0.148	23.75±4.34	23.76±3.70	0.989	−0.002
RDCI (mean±SD)	0.31±0.74	0.34±0.73	0.768	−0.047		0.34±0.73	0.920	0.017

PLA, posterolateral approach; DAA, direct anterior approach; SMD, standardized mean difference; SD, standard deviation; BMI, body mass index; RDCI, rheumatic disease comorbidity index.

protein (CRP), hemoglobin, and albumin were collected.

The surgical data included the type of anesthesia, size of the acetabular cup and femoral head, number of screws, and type of femoral prosthesis and bearing surface. Patients undergoing bilateral surgery were considered as two independent records, although they were not included in the matched groups simultaneously.

Outcome measurement

The patient-reported outcome measures (PROMs) used for this study were Bath Ankylosing Spondylitis Disease Activity Index (BASDAI),

TABLE II
Baseline characteristics and surgical data of the matched patients

	DAA (n = 41)			PLA (n = 123)				
Variables	n	%	Mean±SD	n	%	Mean±SD	t/χ^2	*p*
Left side (%)	17	41.46		65	52.85		1.593	0.207
Positive Thomas sign (%)	35	85.37		98	79.67		0.650	0.420
Bony fusion (%)	13	31.71		21	17.07		4.007	0.045
Flexion contracture (°)			20.85±11.23			19.84±12.48	0.463	0.644
ROM (°)			68.17±68.04			79.02±56.47	–0.921	0.361
HGB (g/dL)			130.59±18.28			134.37±19.47	–1.095	0.275
ESR (mm/h)			25.56±23.47			25.57±18.64	–0.002	0.999
CRP (mg/L)			22.17±23.16			24.32±25.87	–0.472	0.638
ALB (g/L)			44.12±3.43			43.66±6.05	0.459	0.647
Preoperative BASDAI			3.83±1.59			3.98±1.82	–0.461	0.645
Preoperative BASFI			49.98±15.85			56.68±19.77	–1.970	0.051
Preoperative SF-12 PCS			35.60±7.49			34.55±8.61	0.696	0.487
Preoperative SF-12 MCS			43.47±7.29			41.89±7.62	1.158	0.249
Preoperative HHS			37.73±8.52			36.09±11.59	0.971	0.334
Bilateral hip involvement with THA (%)	26	63.41		50	40.65		6.411	0.011
General anesthesia (%)	16	39.02		56	45.53		0.532	0.467
Cup diameter (%)							1.492	0.474
≤ 52 mm	14	34.15		43	34.96			
52-56 mm	23	56.10		59	47.97			
> 56 mm	4	9.76		21	17.07			
Head diameter (%)							0.751	0.687
28 mm	1	2.44		7	5.69			
32 mm	10	24.39		27	21.95			
36 mm	30	73.17		89	72.36			
Number of screws			1.85±0.53			1.63±0.99		
Stem design (%)							1.367	0.713
Modular	0	0.00		2	1.63			
Anatomic	0	0.00		1	0.81			
Cylinder	0	0.00		1	0.81			
Taper	41	100.00		119	96.75			
Bearing surface (%)							3.059	0.217
CoC	28	68.29		84	68.29			
CoP	12	29.27		39	31.71			
MoP	1	2.44		0	0.00			

DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; ROM, range of motion; HGB, hemoglobin; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein; ALB, albumin; BASDAI, Bath ankylosing spondylitis disease activity index; BASFI, Bath ankylosing spondylitis function index; SF-12 PCS, Short-form 12 physical component score; SF-12 MCS, short-form 12 mental component score; HHS, Harris hip score; THA, total hip arthroplasty; CoC, ceramic on ceramic; CoP, ceramic on polyethylene; MoP, metal on polyethylene.

Bath Ankylosing Spondylitis Functional Index (BASFI), and 12-Item Short Form Health Survey (SF-12). The PROMs were collected preoperatively and postoperatively via clinic appointments or telephone interviews. The Harris Hip Score (HHS) was also recorded. At the final follow-up, the patients were asked about their ability to achieve a 90° hip flexion, difficulties with putting on socks, and overall satisfaction with the surgery. The difficulty of putting on socks was classified into five level and overall satisfaction was rated on a four-level scale. Any postoperative complications, including periprosthetic fractures, neurovascular injuries, dislocations, and infections, were also recorded. Postoperative radiographs were used to measure acetabular abduction and anteversion angles,[10] acetabular and femoral component offsets, and bilateral leg length discrepancy (LLD). The proportion of acetabular components positioned within the Lewinnek safe zone was also calculated.[10] All radiographic measurements were performed using RadiAnt DiCOM Viewer (version 2021.1). Measurements were conducted by a senior arthroplasty surgeon who was blinded to the surgical approach.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. For continuous variables, the Shapiro-Wilk test was first used to assess normality, and the independent samples t-test was applied to evaluate the differences in normally distributed variables between the two groups. To compare the proportions of categorical variables, the Pearson chi-square test or Fisher exact test were utilized. A two-sided p value of <0.05 was considered statistically significant.

RESULTS

There were 164 hips with AS for which THA was performed, with 41 and 123 hips in the DAA and PLA groups. The mean BMI was 23.10±4.63 kg/m^2. All hips on which DAA-THA was performed were successfully matched to those on which PLA-THA was performed (1:3). After propensity score-matching, no significant differences were observed between the two groups in any of the demographic variables ($p > 0.05$) (Table I).

TABLE III
Patient-reported outcome measures of the matched patients

	DAA (n = 41)			PLA (n = 123)				
Variables	n	%	Mean±SD	n	%	Mean±SD	t/χ^2	*p*
Postoperative BASDAI			3.11±1.69			2.52±1.87	1.783	0.077
Postoperative BASFI			37.05±15.82			35.31±20.76	0.490	0.625
Postoperative PCS			44.09±8.43			45.93±8.39	-1.213	0.227
Postoperative MCS			52.81±6.04			51.13±7.39	1.319	0.189
Postoperative HHS			82.66±8.45			81.78±10.82	0.473	0.637
Hip flexion over 90° (%)	34	82.93		75	60.98		6.648	**0.010**
Putting-on-socks limitation (%)							11.593	**0.003**
Unable/severe	4	9.76		46	37.40			
Moderate	24	58.54		45	36.59			
None/mild	13	31.71		32	26.02			
Satisfaction (%)							1.562	0.690
Very satisfied	21	51.22		59	47.97			
Satisfied	12	29.27		35	28.46			
General	6	14.63		26	21.14			
Unsatisfied	2	4.88		3	2.44			
Complication (%)	2	7.32		5	4.07		0.175	0.676
Periprosthetic fracture	3	7.32		3	2.44		0.923	0.337
Nerve injury	0	0.00		2	1.63		-	1.000

DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; BASDAI, Bath ankylosing spondylitis disease activity index; BASFI, Bath ankylosing spondylitis function index; SF-12 PCS, Short-form 12 physical component score; SF-12 MCS, short-form 12 mental component score; HHS, Harris hip score.

TABLE IV
Radiological outcomes of the matched patients

Variables	DAA (n = 41) n	%	Mean±SD	PLA (n = 123) n	%	Mean±SD	t/χ^2	*p*
Acetabular inclination (°)			40.76±4.76			40.80±6.59	0.034	0.973
Acetabular anteversion (°)			17.10±6.60			20.68±8.73	2.175	**0.031**
Acetabular offset (mm)			36.27±5.03			37.14±4.48	0.769	0.444
Femoral offset (mm)			35.27±7.73			39.33±8.54	-1.986	0.051
Radiological LLD (mm)			-0.08±4.12			0.43±5.43	-0.494	0.622
Lewinnek safe zone (%)	34	82.93		74	60.16		7.086	**0.008**

DAA, direct anterior approach; PLA, posterolateral approach; SD, standard deviation; LLD, leg length discrepancy, defined as the distance from the center of rotation to the most prominent point of the lesser trochanter on the operated side minus that on the contralateral side.

The preoperative laboratory tests and clinical scores showed no significant differences between the two groups ($p > 0.05$). The proportion of positive Thomas signs, degree of flexion contracture, and total ROM of the hip also showed no significant differences ($p > 0.05$). However, the DAA group exhibited higher rates of bony fusion before surgery, compared to the PLA group (31.71% *vs.* 17.07%, $p = 0.045$). There were no significant differences in surgical data between the two groups, except that the DAA group had a higher number of patients undergoing bilateral surgery, compared to the PLA group (63.41% *vs.* 40.65%, $p = 0.011$) (Table II).

The mean follow-up duration was 68.05±38.09 (range, 13 to 183) months. There were no significant differences in clinical scores or overall satisfaction at the final follow-up ($p > 0.05$). However, the DAA group included a higher proportion of patients achieving hip flexion over 90° (82.93% *vs.* 60.98%, $p = 0.010$), with fewer patients reporting difficulties with putting on socks, compared to the PLA group ($p = 0.003$). There was no significant difference in the incidence of postoperative complications, and neither group experienced dislocations or infections ($p > 0.05$) (Table III).

No significant differences were observed between the two groups in acetabular inclination, acetabular offset or LLD ($p > 0.05$) (Table IV). The PLA group exhibited a larger femoral offset; however, the difference did not reach statistical significance (39.33±8.54 *vs.* 35.27±7.73 mm, $p = 0.051$). Notably, the DAA group demonstrated a smaller acetabular anteversion angle (17.10±6.60 *vs.* 20.68±8.73°, $p = 0.031$), and the proportion of acetabular components positioned within the Lewinnek safe zone was higher than that in the PLA group (82.93% *vs.* 60.16%, $p = 0.008$) (Figure 2).

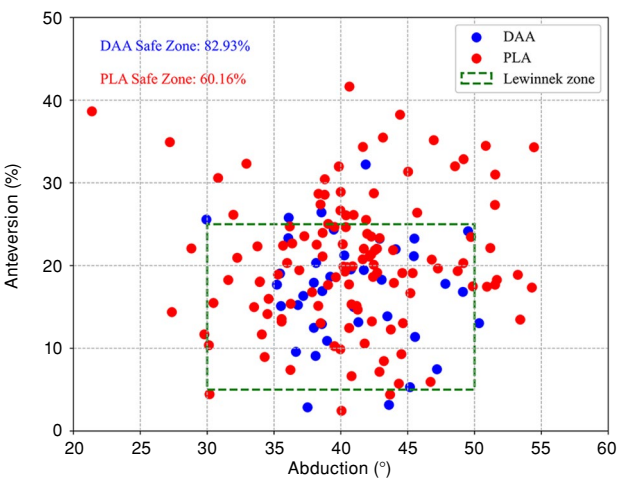

FIGURE 2. Postoperative acetabular anteversion and abduction angles in the DAA and PLA groups.
DAA, direct anterior approach; PLA, posterolateral approach.

DISCUSSION

In the present study, we compared the clinical and radiological outcomes of the DAA and the traditional PLA for THA in patients with AS. Our study results showed that, among patients with AS who underwent either DAA- or PLA-THA, there were no significant differences in postoperative complications, clinical scores or overall satisfaction. However, the DAA group exhibited better hip flexion function and fewer functional limitations in putting on socks, compared to the PLA group. These results demonstrate that DAA-THA is both safe and effective in patients with AS, and it can favorably address their postoperative daily living needs. Besides, the higher proportion of acetabular components placed within the Lewinnek safe zone after DAA indicates more accurate acetabular implantation with this approach.

Previous studies have shown that patients with AS undergoing THA have favorable long-term follow-up outcomes, with significant improvements in both symptoms and function.[11-13] Bukowski et al.[12] reported that among 309 patients with AS who underwent THA, HHS improved significantly, with a 17.5% revision rate at 20 years postoperatively. However, some studies have found that AS increases the incidence of complications and revisions following THA.[4,14] The surgical approach plays a significant role in postoperative functional recovery following THA. Currently, most patients with AS undergo PLA-THA, which provides optimal exposure and facilitates posterior soft tissue release.[8] Of note, DAA, an innovative approach for THA, was initially proposed and progressively refined by Heuter, Smith-Peterson, and others.[15] Recently, it has attracted increasing attention due to its unique advantages. Chen et al.[7] conducted a review of 22 meta-analyses that compared DAA with other approaches. Most of the studies found that DAA achieved better functional outcomes in the early postoperative period, with no significant differences in the incidences of complications. The incision made in DAA is small, and the procedure accesses the hip joint through the intermuscular space, resulting in less tissue damage during surgery.[16,17] Proponents of the DAA approach believe that it allows patients to begin postoperative rehabilitation exercises earlier and reduces the risk of posterior dislocation by avoiding interference with the posterior soft tissues of the hip.[18,19]

Direct anterior approach has been used in THA for bony fusion or ankylosed hip. Scemama et al.[20] reported on the use of DAA in the conversion of hip fusion to THA. They found that the procedure resulted in less intraoperative trauma, provided a clearer surgical view, and was associated with a lower incidence of heterotopic ossification postoperatively. Subsequent studies have reported the use of DAA for THA in patients with AS, demonstrating satisfactory clinical outcomes. Wu et al.[9] reported on 39 fused hips (29 preoperatively diagnosed with AS) undergoing DAA-THA in the lateral decubitus position, compared to a PLA-THA group. The authors found that, at three months postoperatively, the DAA-THA group had better clinical scores and ROM, compared to the PLA-THA group; however, no significant differences were observed at one year. In cases of ankylosing hips, the PLA presents challenges in exposing the femoral neck and acetabulum, requiring division of the external rotator muscles. In contrast, the DAA facilitates clear exposure of both the acetabulum and proximal femur, allowing direct visualization and release of the anterior soft tissues while minimizing the risk of neurovascular injury.[9] Dong et al.[8] also reported a comparative study of lateral decubitus DAA and PLA for fused hips. They found that the DAA achieved accurate prosthesis placement and better early postoperative functional recovery (with less blood loss and muscle damage); however, at one year, the scores of both groups were similar. Additionally, in cases with preoperative flexion contracture, the DAA group showed a better ROM at one month, possibly due to soft tissue release during surgery. Mimendia et al.[21] reported on the use of the supine DAA on a regular surgical table, combined with intraoperative fluoroscopy for precise prosthesis placement.

Compared to previous studies, this study included a larger number of cases with AS who underwent DAA-THA, and a longer follow-up period. Although there were no significant differences in clinical scores and satisfaction between the two groups, the DAA group showed significantly better hip flexion and sock-and-shoe-donning ability. Early postoperative rehabilitation plays a critical role in functional recovery following THA.[22] The DAA results in less soft tissue damage and postoperative pain, allowing for early rehabilitation exercises to restore joint ROM and muscle strength.[18] From a clinical perspective, our findings suggest that DAA may offer potential advantages in patients with AS, particularly in terms of postoperative hip flexion and acetabular component positioning.

The recovery of hip flexion and the ability to perform daily living activities, such as squatting, are key factors influencing patient satisfaction after THA.[23] Zhang et al.[6] found that, although patients with AS were usually satisfied with THA outcomes, a high incidence of poor postoperative hip flexion function persisted. In the aforementioned study, only 32.9% of patients achieved hip flexion over 90° postoperatively, whereas 60.4% experienced varying degrees of difficulty with putting on shoes and socks. These outcomes were associated with preoperative flexion contractures, heterotopic ossification, preoperative CRP levels, and femoral head prosthesis size. Patients have certain expectations regarding improvement in shoe-and-sock-donning ability after THA; however, a portion of them find these expectations unmet.[24,25] Previous studies have found that, in addition to

factors such as prosthesis size [26] and intraoperative ROM,[27] the surgical approach also plays a significant role. Sakai et al.[28] found that, over four years postoperatively, 94% of patients in a DAA group were able to cut their toenails, compared to only 83% in a PLA group. This study also confirmed that the DAA aids in the recovery of hip flexion function in patients with AS, which may be attributed to the following factors. Firstly, spinal stiffness in patients with AS demands greater hip flexion ROM for tasks such as shoe and sock donning, compounded by a narrower acetabular safe zone. The DAA preserves posterior soft tissues and allows for accurate prosthesis positioning, reducing the risk of dislocation and impingement during deep flexion. Secondly, the DAA allows for earlier postoperative rehabilitation, facilitating the recovery of hip joint ROM. As a true intermuscular and internervous approach, DAA minimizes disruption of periarticular muscles and preserves posterior soft-tissue structures, which are closely associated with postoperative hip mobility. In patients with AS, who typically present with pronounced periarticular stiffness and reduced soft-tissue elasticity, the muscle-sparing nature of DAA may be particularly advantageous. Thirdly, the DAA may be associated with a lower incidence of heterotopic ossification,[29] helping to prevent hip joint stiffness. Finally, patients may use various movement patterns, such as combined knee flexion and hip extension, to put on shoes and socks.[26] In patients with AS, abnormal spinal-pelvic alignment leads to hip flexion contractures. [5] The DAA releases anterior soft tissues, restoring hip extension range and enabling tasks such as shoe and sock donning.

In the current study, the DAA group demonstrated smaller acetabular anteversion and a higher proportion of components within the Lewinnek safe zone. Consistent with prior reports, this may reflect the more stable pelvic orientation in the supine position during DAA, enabling more accurate control of anteversion, together with the routine use of intraoperative fluoroscopy to assist precise component placement. [30,31] We also observed a smaller femoral offset in the DAA group, although the difference did not reach statistical significance. This finding is consistent with prior reports suggesting that the DAA allows more accurate restoration of the native offset, whereas the PLA may require deliberate offset augmentation to enhance posterolateral stability.[32,33] The radiographic findings further support the use of DAA in patients with AS. More accurate component placement may help reduce complications such as dislocation, while improved restoration of native anatomy may contribute to better hip function.

Nonetheless, this study has several limitations. First, its retrospective design is inherently subject to selection bias and limits the ability to establish causal relationships. Although propensity score matching was applied to balance measured baseline characteristics between groups, residual confounding from unmeasured or unavailable variables cannot be completely excluded. Second, this was a single-center study, which may restrict the generalizability of our findings. Third, radiographic measurements may be affected by inherent measurement variability. Additionally, we did not investigate the specific causes or postures adopted by patients with difficulty in shoe and sock donning. Future multi-center, prospective studies are warranted to further validate the advantages of DAA in patients with AS.

In conclusion, although both surgical approaches are effective for managing hip involvement in ankylosing spondylitis undergoing THA, the DAA may offer functional benefits and improved prosthetic alignment. These advantages support its consideration as a favorable surgical option in appropriately selected patients, while further prospective studies with larger cohorts are warranted to confirm these findings and assess long-term outcomes.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Y.Z., L.Z.: Idea; X.W., Y.Z.: Design; Y.Z.: Control; D.C., T.B.: Data collection; S.G.: Analysis; S.M., T.B.: Literature review; X.W., S.G.: Writing; Y.Z., S.M.: Crtitical review.

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