A Systematic Review and Meta-analysis of Direct Anterior Approach Versus Posterolateral Approach in Total Hip Arthroplasty

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Research article

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Abstract

Background: To evaluate the difference of clinical results between DAA and PLA in primary THA.

Methods: The PubMed, Embase and the Cochrane Library were searched by computer to collect and compare clinical randomized controlled trials of primary THA through DAA and PLA. The clinical outcome measures include operation time, total blood loss, acetabular abduction angle, acetabular anteversion angle, Harris hip score and postoperative dislocation rate. The Revman 5.3 software provided by the Cochrane Collaborat Network was used for Meta analysis of the data.

Results: A total of 654 patients were included in 8 studies, including 328 patients in DAA group and 326 patients in PLA group. Meta-combined results, The number of acetabular abduction angle in DAA group is smaller than that in PLA group \[MD =-0.87, 95\%CI(-1.69 \sim -0.04), p = 0.04\], and the number of acetabular anteversion angle in DAA group is also smaller than that in PLA group \[MD =-4.25, 95\%CI(-4.96 \sim -3.54), p < 0.00001\], the differences are statistically significant. 6 weeks after operation, the Harris hip score of DAA was higher than that of PLA \[MD = 5.35, 95\%CI(2.38 \sim 8.32), P = 0.0004\], and the difference was statistically significant. For the total Harris hip score, DAA is higher than PLA, and the difference is statistically significant \[MD = 2.3, 95\%CI (0.19 \sim 4.41), P = 0.03\]; However, other results were not statistically significant.

Conclusion: Compared with PLA, DAA can accelerate postoperative rehabilitation of patients, and at the same time can obtain better acetabular prosthesis location.

Background

Total hip arthroplasty (THA), which can solve patients' pain, correct joint deformities and restore hip function, is one of the most successful orthopedic surgeries and has been recognized by more and more patients[1-6]. However, there are still about 7-15% patients who are not satisfied with THA due to postoperative pain and slow functional recovery[7-8]. With the continuous improvement of THA technology, the options of surgical approach are increased. Choosing the optimal surgical approach can reduce the length of hospital stay and postoperative functional recovery time, thus effectively improving patient satisfaction[9-10]. As one of the most common approaches to THA[11], the traditional posterolateral approach (PLA) has the advantages of simple operation and easy exposure of visual field; However, the PLA needs to cut off the external rotation muscle group at the small trochanter stop point, which causes great damage to muscle tissue, and has the risks of long postoperative recovery time, high joint dislocation rate, etc[12].

In recent years, with the development of minimally invasive and accelerated rehabilitation surgery, patients' demand for less invasive surgery technology has increased significantly. Minimally invasive surgery has become the mainstream of surgery. Direct anterior approach (DAA) is a minimally invasive hip surgery technology, which can reduce muscle injury, reduce postoperative pain and accelerate postoperative rehabilitation, now more and more orthopedic doctors pay attention to it[13-17]. The DAA,
which exposes the hip joint through the neuromuscular space between the tensor fascia lata and the sartorius, shortens the length of the incision and reduces the stripping of muscle and soft tissue[18-19], is a truly minimally invasive procedure[20-21]. However, its clinical results are controversial. It has been reported that intraoperative blood loss will increase when DAA is used for THA[22], and DAA has a certain learning curve[23], while the incidence of postoperative complications will significantly increase when surgeons perform THA during the learning curve[24]. DAA has a high technical requirement for surgery. Statistics show that most THA is performed by posterolateral or lateral approaches, and only less than 5% of surgeons adopt DAA approach[25-26]. A meta analysis conducted by Kucukdurmaz et al. [27] showed that DAA approach achieved better postoperative functional results than other approaches without increasing the risk of complications; however, this study only compared the functional results at 6 weeks postoperatively, and there was no evidence to support the pros and cons between the two after 6 weeks postoperatively. Moreover, DAA was compared with the lateral approach in some of the included studies, which may bias the final results.

Therefore, we included the randomized controlled trials (RCTs) of primary THA between DAA and PLA for meta analysis, in order to compare the clinical efficacy of THA between DAA and PLA, and provide reference for clinicians. We hypothesized that DAA can accelerate postoperative recovery of patients and obtain better acetabular prosthesis position than PLA in THA.

Methods

Literature retrieval and inclusion criteria

Computer searches of PubMed (1980 to February 2020), Embase (1980 to February 2020), and the Cochrane Library (Issue 1, 2020). The language limit is English. Research inclusion criteria: comparison of RCT between DAA and PLA for the primary unilateral THA; randomized method was used to determine the matching study of primary bilateral THA with DAA on one side and PLA on the other side; outcome measures include operation time, total blood loss, acetabular anteversion, acetabular abduction angle, Harris hip score at 6 weeks, 3 months, 6 months, 12 months and postoperative dislocation rate.

Data extraction and quality evaluation

The two authors independently extracted and cross-checked the following information: first author name, time of publication, number of cases, sex ratio, average age, BMI, outcome measures, and follow-up duration.

The two authors independently evaluated the quality of the included studies, and discussed and resolved any disputes between them. The included study was assessed in detail in accordance with the RCT Risk assessment tool recommended by Cochrane Reviewer ‘Handbook 5.3, which was divided into the following seven aspects: 1. Whether randomly generate a sequence; 2. Whether or not to allocate concealment; 3. Were researchers and subjects blinded; 4. Whether to apply blindness to the evaluation of results; 5. Whether the resulting data is complete; 6. Is there any selective reporting of results; 7. Is there
any other bias. Low risk indicates low risk bias, Unclear risk indicates inaccurate risk bias, and High risk indicates high risk bias.

Statistical analysis

Meta-analysis was conducted using Revman 5.3 statistical software provided by Cochrane Collaboration Network. The heterogeneity analysis among the studies was conducted by $\chi^2$ test, and the test level was $\alpha = 0.1$. When there is no statistical heterogeneity among the studies, the fixed effect model is used for analysis. On the contrary, the random effect model is adopted. Weighted mean difference (WMD) and 95% CI were used for the combined analysis of continuous variables, while risk ratio (RR) and 95% CI were used for dichotomous variables. When there is statistical heterogeneity between the studies, we use the method of eliminating one study to analyze the source of heterogeneity and to verify the reliability of the results.

Results

Search results and the basic characteristics of the research

The flow chart of literature retrieval is shown in Figure 1. A total of 256 related articles were retrieved according to the search strategy. By reading the title, abstract and full text, a total of 8 studies met the inclusion criteria[28-35] and were published from 2011 to 2019. 654 patients were included in these studies, including 328 patients in DAA group and 326 patients in PLA group. Follow-up duration ranged from 2 weeks to 1 year. The basic characteristic of the included studies can be seen in Table 1. Randomized programs included in the study include randomization schedule[29], computer generated random numbers[35], random envelopes[32], and unreported[28,30,31,33,34]. In the randomly generated sequence, 3 studies are of low risk bias[29,32,35] and 5 studies are of uncertain risk bias[28,30,31,33,34]. The risk of hidden grouping bias is low in 3 studies[32-34], high in 2 studies[28,30], and inaccurate in 3 studies[29,31,35]. In three studies[32,34,35], the researchers and subjects were blinded and the risk of bias was low; in five studies[28-31,33], the researchers and subjects were not blinded and the risk of bias was high. In the result evaluation blindness, 2 studies[32,33] had low risk bias, 5 studies[28-31,34] had high risk bias, and 1 study[35] had inaccurate risk bias. The results of 5 studies [28,29,32,34,35] were complete with low risk bias. Data in the 3 studies [30,31,33] were incomplete and the risk bias was high. The risk of selective reporting was low in seven studies[28-29,31-35], while the risk of selective reporting was inaccurate in one study[30]. Eight studies had a low risk of other bias[28-35]. Cochrane bias risk assessment is shown in Figures 2 and 3.

Results of meta-analysis

Operation time

Six studies[28-30,32-34] analyzed operative time and collected data on a total of 503 primary THAs, including 250 patients in the DAA group and 253 patients in the PLA group. Comparison of operative time
for two different approaches. Because there was significant heterogeneity among the results of each study ($I^2>50\%$), heterogeneity could not be eliminated by sensitivity analysis and subgroup analysis, so a random effects model was used for the analysis. The results showed that the operative time of DAA and PLA were equivalent [MD = 7.49, 95%CI(-4.01 ~ 18.98), P = 0.2], the difference was not statistically significant, as shown in Figure 4.

**Total blood loss**

Four studies[28-29,32-33] analyzed blood loss, but one of them [32] described intraoperative blood loss specifically, so it was not included for analysis. A total of 190 patients with primary THA were included in the 3 studies[28-29,33], among which 95 patients received DAA and 95 patients received PLA. The difference in total blood loss between the two approaches was statistically significant [MD = 114.82, 95%CI(69.33 ~ 160.31), P < 0.00001], as shown in Figure 5. Due to the significant heterogeneity ($I^2>50\%$) among the study results, sensitivity analysis revealed that the heterogeneity came from Barrett et al[29], after removing this study, found that the total bleeding in the DAA and PLA groups was comparable [MD = 50.04, 95%CI(-10.31 ~ 110.4), P = 0.1], the difference was not statistically significant, as shown in Figure 6.

**Acetabular abduction angle**

Six studies[28-30,32,34,35] analyzed the degree of acetabular abduction angle, including 557 primary THA patients, including 277 patients in DAA group and 280 patients in PLA group. There was no statistically significant difference in the degree of acetabular abduction angles between the two surgical approaches [MD =-0.45, 95%CI(-1.24 ~ 0.35), P = 0.27], as shown in Figure 7. Because there was significant heterogeneity ($I^2>50\%$) among the study results, sensitivity analysis revealed that the heterogeneity came from Barrett et al[29], after removing this study, it was found that the degree of acetabular abduction angles in the DAA approach was smaller than that in the PLA approach [MD =-0.87, 95%CI(-1.69 ~-0.04), P = 0.04], and the difference was statistically significant, as shown in Figure 8.

**Acetabular anteversion angle**

Four studies[29,30,32,34] analyzed the degrees of acetabular anteversion angle and included 400 patients with primary THA, 198 patients in the DAA group and 202 patients in the PLA group. The difference of acetabular anteversion angle between the two surgical approaches is statistically significant [MD =-4.03, 95%CI(-4.73 ~-3.33), P < 0.00001], as shown in Figure 9. Due to the heterogeneity ($I^2>50\%$) between the results of the studies, sensitivity analysis revealed that the heterogeneity originated from Cheng et al.[34]. After removing this study, it was found that the acetabular anteversion angle degree of the DAA was still smaller than that of the PLA [MD =-4.25, 95%CI(-4.96 ~-3.54), P < 0.00001], and the difference was statistically significant, as shown in Figure 10.

**Harris hip score at 6 weeks, 3 months, 6 months, 12 months**
Harris hip scores were reported in 7[28-33,35] out of 8 studies[28-35], while 1[35] of the 7 studies lacked data and was therefore excluded.

Four studies[29-31,33] were recorded for Harris hip score at 6 weeks, two studies[29,32] were recorded for Harris hip score at 3 months, two studies[29,32] were recorded for Harris hip score at 6 months, and two studies[29,30] were recorded for Harris hip score at 12 months. A total of 5 studies were included. Meta-analysis was performed in subgroups according to the different of postoperative follow-up time, and 424 patients underwent primary THA, including 214 patients in DAA group and 210 patients in PLA group. Because of the heterogeneity among the results (I²> 50%), a random effects model was used for the Meta-analysis. 6 weeks after operation, the Harris hip score of DAA was higher than that of PLA [MD = 5.35, 95%CI(2.38 ~ 8.32), P = 0.0004], and the difference was statistically significant. 3 months after operation [MD = 2.82, 95%CI (-3.54 ~ 9.17), P = 0.39], 6 months after operation [MD = 0.67, 95%CI (-1.87 ~ 3.21), P = 0.6], 12 months after operation [MD = -0.42, 95%CI (-2.42 ~ 1.58), P = 0.68], the difference was not statistically significant. However, for the total Harris hip score in the follow-up of 4 periods of 5 studies, DAA is higher than PLA, and the difference is statistically significant [MD = 2.3, 95%CI (0.19 ~ 4.41), P = 0.03], as shown in Figure 11.

Postoperative dislocation rate

Four studies reported postoperative dislocation rates and included 380 patients with primary THA, including 188 patients in the DAA group and 192 patients in the PLA group. The incidence of postoperative dislocation was compared between the two approaches. As there is no heterogeneity (I² ≤ 50%) between the results of the two approaches, the fixed-effects model was used for Meta-analysis. The results showed that the postoperative dislocation rates of DAA was the same as that of PLA [RR = 0.80, 95%CI(0.20 ~ 3.19), P = 0.75], and the difference was not statistically significant, as shown in Figure 12.

Discussion

In this paper, eight high-quality RCT studies were included and meta-analysis was conducted from four aspects, namely perioperative period, radiology, clinical results and postoperative complications. The results showed that compared with the PLA group, the DAA group had better postoperative hip function recovery and more accurate placement of acetabular cups. However, in the perioperative indicators, there was no difference in the operative time and total blood loss of DAA compared with PLA, and there was no difference in the incidence of dislocation rate in postoperative complications.

As for the operation time, some researches believe that DAA takes more time than other approaches[36], which reflects that DAA approach has certain technical difficulties. However, in this meta-analysis, there is no difference between DAA group and PLA group in terms of operation time and total blood loss. Therefore, it can be judged that when orthopedic doctors master DAA approach skillfully, DAA will not increase the difficulty in operation compared with the traditional PLA.
The position of acetabular components affects the function and service life of THA implants[37-38]. In particular, the position of the acetabular cup is crucial for hip stability; Incorrect cup position will increase the risk of dislocation of prosthesis. Compared with other approaches, the position of acetabular cup in DAA patients changed little after operation[39-40]. In this meta-analysis, the DAA group had a smaller acetabular antegrade Angle and acetabular abduction Angle than the PLA group, indicating that the position of acetabular cup through the DAA was more accurate. The position of the acetabular prosthesis is determined by intraoperative positioning, functional pelvic tilt, and sagittal plane balance. The DAA is performed with the patient in the supine position, which helps to re-establish functional pelvic orientation[41] and allows the pelvis to remain stable, reducing errors in acetabular implant placement[42]. Meanwhile, in the supine position, the surgeon can flexibly adjust the acetabular position and place it accurately, while in the lateral position, the tilt direction of the pelvis is not easy to grasp, which may easily lead to the inaccurate placement of the acetabular prosthesis[37].

According to the literature, DAA is a minimally invasive surgical approach that has little impact on early functional recovery[43-44], which has been confirmed by Barrett et al.[28] through serum enzymatic test; in addition, the joints can be moved freely after DAA, which is conducive to rapid recovery. However, after PLA surgery, activities should be reduced, which will affect the functional recovery of patients[45]. Therefore, through meta-combined analysis, we found that in Harris hip score, DAA surgical approach is better, that is, the early functional recovery of patients in DAA group is faster than that in PLA group. However, it is not enough to analyze the functional recovery after THA only from the operative approach. Kirsten et al.[45] think that besides the operative approach, the operator should pay more attention to the operative experience, the rapid postoperative recovery plan, the choice of patients, etc. instead of only considering the approach.

Evaluations vary on the issue of postoperative complication rates of DAAs. Dislocation is a relatively common postoperative complication of THA, and the possibility of postoperative dislocation exists regardless of approach used. DAA has been reported to have a fairly high complication rate in some studies[46], among them, the postoperative dislocation rate of THA performed in this approach was 0.96-1.5%[47-48]. There are also studies suggesting that the incidence of postoperative complications of DAA is very low[49-50]. Jewett et al.[51] indicated that the postoperative dislocation rate of this approach is only 0.88%, which is significantly lower than other surgical approaches[52]. The reason is that DAA is the intermuscular gap approach, which does not destroy the posterior joint capsule and external rotator muscle group, and maintains the firmness of the joint[53]. However, the incidence of postoperative dislocation rates in the DAA and PLA groups were the same in this meta-analysis, suggesting that if the surgeon has gone through the DAA learning curve and has sufficient experience, the incidence of postoperative complications in the DAA approach is essentially unchanged compared with other approaches[54-56]. Nonetheless, patients in the PLA group have to reduce their activities after surgery to prevent dislocation, whereas patients in the DAA group do not have to be restrained[45], have better postoperative recovery, and have a better quality of life.
At present, our research has several advantages. First, we believe that meta-analysis using the Cochrane method allowed us to include studies with a higher level of evidence. Second, to avoid bias in the review process, we conducted a thorough literature search of randomized controlled trials, contacting the authors for more detailed data if necessary. Thirdly, the literatures we included were randomized controlled trials, and some of them had not been included and analyzed before, and some of them also used blind method.

At the same time, this meta-analysis also has some limitations. First of all, the types of prostheses used in the included studies were inconsistent, which could have biased the results, and some outcome indicators were included in too few studies to draw accurate conclusions. Second, the Harris hip scores included in the analysis had a relatively short follow-up period, and a longer period of observation is needed to determine the clinical efficacy of DAA. This paper then analyzes postoperative complications, but only the risk of dislocation is analyzed, and there is no relevant comparative analysis of other types of complications. Finally, in the included studies, there is a high risk of bias in both researcher and subject blinding and outcome evaluation blinding, and this bias can affect the final results.

Conclusion

Compared with PLA, DAA can accelerate postoperative rehabilitation of patients, and at the same time can obtain better acetabular prosthesis location. Considering the limitations of this meta-analysis, more high-quality RCT is needed to further determine that the DAA is more advantageous than the PLA.

Abbreviations

THA: Total hip arthroplasty; PLA: Posterolateral approach; DAA: Direct anterior approach; RCTs: Randomized controlled trials; WMD: Weighted mean deviation; RR: Risk ratio; CI: Confidence interval; MD: Mean deviation; BMI: Body mass index

Declarations

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None

Authors' contributions

The following authors designed the study (SZL), collected the data (HHX, JYXL), analysed the data (HHX, JYXL), wrote the initial drafts (HHX), and ensured the accuracy of the data and analysis (SZL, HHX, JYXL). All authors read and approved the manuscript.

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Availability of data and materials

All data were contained in the text and charts of published articles.

Ethics approval and consent to participate

Ethical approval was not necessary because this study is a review of previous RCTs, and we did not obtain any other data from patients. The need for consent to participate is not applicable.

Consent for publication

The co-authors agreed on the final manuscript.

Competing interests

The co-authors claim there was no competition between them.

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**Tables**

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

**Figures**
**Figure 4**

Operation time outcome forest plot analyses

**Figure 5**

Total blood loss outcome forest plot analyses

**Figure 6**

Forest plot of Total blood loss sensitivity analysis for comparison
### Figure 7

Acetabular abduction angle outcome forest plot analyses

| Study or Subgroup | DAA Mean | SD | Total | PLA Mean | SD | Total | Mean Difference IV, Fixed, 95% CI |
|-------------------|----------|----|-------|----------|----|-------|----------------------------------|
| Barrett 2013      | 47.1     | 6.1| 43    | 42.4     | 7.6| 44    | 4.70 [1.81, 7.59]                |
| Bergin 2011       | 46.5     | 3.3| 29    | 46.9     | 5.6| 28    | 0.90 [0.00, 4.60]                |
| Bon 2019          | 37.7     | 4.2| 50    | 39.6     | 6.87| 50    | -1.86 [-4.08, 0.37]              |
| Cheng 2017        | 46.2     | 6.1| 35    | 45.9     | 8.0 | 38    | 0.30 [-2.95, 3.55]               |
| Rodriguez 2014    | 40.5     | 5  | 60    | 40.7     | 7.4 | 60    | 1.23 [0.00, 2.26]                |
| Zhao 2017         | 40.3     | 2.8| 60    | 41.8     | 3.4 | 60    | -1.60 [-2.61, -0.59]             |

Total (95% CI) 277 / 280 100.0% -0.45 [-1.24, 0.35]

Heterogeneity: $\chi^2 = 20.29, \text{df} = 5 (P = 0.001); I^2 = 75\%$

Test for overall effect: $Z = 1.11 (P = 0.27)$

### Figure 8

Forest plot of acetabular abduction angle sensitivity analysis for comparison

| Study or Subgroup | DAA Mean | SD | Total | PLA Mean | SD | Total | Mean Difference IV, Fixed, 95% CI |
|-------------------|----------|----|-------|----------|----|-------|----------------------------------|
| Barrett 2013      | 47.1     | 6.1| 43    | 42.4     | 7.6| 44    | 4.70 [1.81, 7.59]                |
| Bergin 2011       | 46.5     | 3.3| 29    | 46.9     | 5.6| 28    | 0.90 [0.00, 4.60]                |
| Bon 2019          | 37.7     | 4.2| 50    | 39.6     | 6.87| 50    | -1.86 [-4.08, 0.37]              |
| Cheng 2017        | 46.2     | 6.1| 35    | 45.9     | 8.0 | 38    | 0.30 [-2.95, 3.55]               |
| Rodriguez 2014    | 40.5     | 5  | 60    | 40.7     | 7.4 | 60    | 1.23 [0.00, 2.26]                |
| Zhao 2017         | 40.3     | 2.8| 60    | 41.8     | 3.4 | 60    | -1.60 [-2.61, -0.59]             |

Total (95% CI) 234 / 236 100.0% -0.87 [-1.69, -0.04]

Heterogeneity: $\chi^2 = 7.13, \text{df} = 4 (P = 0.13); I^2 = 44\%$

Test for overall effect: $Z = 2.06 (P = 0.04)$

### Figure 9

Acetabular anteversion angle outcome forest plot analysis

| Study or Subgroup | DAA Mean | SD | Total | PLA Mean | SD | Total | Mean Difference IV, Fixed, 95% CI |
|-------------------|----------|----|-------|----------|----|-------|----------------------------------|
| Barrett 2013      | 20.1     | 5.9| 43    | 25.8     | 8.1| 44    | -5.67 [-8.67, -2.73]             |
| Cheng 2017        | 24.6     | 8.8| 35    | 20.3     | 10.2| 38    | 4.30 [0.08, 8.66]                |
| Rodriguez 2014    | 13.4     | 3.4| 60    | 17.5     | 9.9| 60    | -4.00 [-5.72, -2.28]             |
| Zhao 2017         | 17.1     | 2.1| 60    | 21.3     | 2.4| 60    | -4.20 [-5.01, -3.39]             |

Total (95% CI) 198 / 202 100.0% -4.03 [-4.73, -3.33]

Heterogeneity: $\chi^2 = 15.40, \text{df} = 3 (P = 0.002); I^2 = 91\%$

Test for overall effect: $Z = 11.29 (P < 0.00001)$
Figure 10

Forest plot of acetabular anteversion angle sensitivity analysis for comparison

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- PRISMA2009checklist.doc
- Table1.pdf