Clinical, Functional and Radiographic Outcomes of Primary Total Hip Arthroplasty between Direct Anterior Approach and Posterior Approach: a Systematic Review and Meta-analysis

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Abstract

Background: The purpose of this systematic review and meta-analysis was to compare the clinical, functional and radiographic outcomes of primary total hip arthroplasty between the direct anterior approach and posterior approach.

Methods: We searched the PubMed, EMBASE databases and Cochrane library from the inception dates to November 1, 2019. And we also searched for the meta-analysis which was published in the past for randomized controlled trials.

Results: A total of 7 randomized controlled trials with 600 participants fulfilled the inclusion criteria. Among these, 301 and 299 patients were in the DAA and PA groups, respectively. DAA was associated with a longer surgery time by a mean of 13.74 min (95% CI 6.88 to 20.61, p < 0.0001, I2=93%). Postoperative early functional outcomes were significantly better in the DAA group than PA group such as Visual Analogue Scale (VAS) postoperative 1 day (MD=-0.65, 95% CI -0.91 to -0.38,p < 0.00001, I2=0%), VAS score postoperative 2 days (MD=-0.67, 95% CI -1.34 to -0.01, p =0.05,I2=88%) and Harris Hip Score (HHS) postoperative 6 weeks(MD=6.05, 95% CI 1.14 to 10.95, p =0.02, I2=52%).There was no significant difference between the DAA and PA groups at length of incision, length of stay(LOS), blood loss, transfusion rates or complication rates. We found no significant difference between the two groups about late functional outcomes such as VAS score postoperative 12 months or HHS scores postoperative 3, 6, 12 months. A significant difference in Radiographic outcomes can not be detected too.

Conclusions: DAA needs longer surgery time than PA in primary total hip arthroplasty. The DAA offers better early functional recovery than PA. There is no significant difference between the two groups in terms of other clinical, complication, late functional and radiographic outcomes. The evidence about the superiority of DAA is insufficient, which needs more research.

Background

With the aging of society, the morbidity of knee and hip osteoarthritis are growing enormous, which caused a huge social and economic burden[1, 2]. Total hip arthroplasty (THA) is recognized as a kind of successful and effective method for end-stage OA[3]. THA surgery has greatly improved the functional status of patients since a half-century ago[4].

Many surgical approaches are used in THA surgery, but there is little evidence to prove which approach gains an advantage[5, 6]. On one hand, the direct anterior approach (DAA) is seen as a kind of true minimally invasive approach because of less muscle damage, which enters the operation area of the hip joint by muscle gap[7, 8].On the other hand, the conventional posterior approach (PA) is the most frequently used surgical approach for THA[9].

Some studies show DAA is inclined to less blood loss, low transfusion rates, shorter surgery times, shorter length of hospital stay (LOS), low postoperative complication rates and better functional recovery[10–17].

Some other studies find higher postoperative complication rates in the DAA group compared with PA group[18, 19], especially the lateral cutaneous nerve of thigh neuropraxia[18, 20]. Several meta-analyses published in the past are not comprehensive and accurate enough. Retrospective studies and non-randomized controlled trials are included in most of the meta-analyses, which leads to indirect evidence[21–23]. The approach by minimally invasive, piriformis preserving approaches and computer-aided technology is also regarded as a standard approach in the study improperly[21–25], which should be avoided strictly for an accurate result. We, therefore, perform a meta-analysis that strictly limits the inclusion conditions and updates the latest published RCTs, in order to compare the clinical, functional and radiographic outcomes of primary total hip arthroplasty between direct anterior approach and posterior approach.

Methods

Search strategies

We performed this study by the Cochrane Handbook for Systematic Reviews of Interventions [26] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[27]. We searched the PubMed, EMBASE databases and Cochrane library from the inception dates to November 1, 2019. And we also searched for the meta-analysis which is published in the past for randomized controlled trials. We used the keywords "Arthroplasty, Replacement, Hip" and "approach" to identify published RCTs and we did not set any language restriction.

Electronic search strategy of PubMed: ((((((((((randomized controlled trial [pt]) OR controlled clinical trial [pt]) OR randomized [tiab]) OR placebo [tiab]) OR clinical trials as topic [mesh: noexp]) OR randomly [tiab]) OR trial [ti])) NOT ((animals [mh] NOT humans [mh])))) AND ((approach[Title/Abstract]) AND ((((((((((((((((((("Arthroplasty, Replacement, Hip"[Mesh]) OR Arthroplasties, Replacement, Hip[Title/Abstract]) OR Arthroplasty, Hip Replacement[Title/Abstract]) OR Hip Prosthesis Implantation[Title/Abstract]) OR Hip Prosthesis Implantations[Title/Abstract]) OR Implantation, Hip Prosthesis[Title/Abstract]) OR Implantations, Hip Prosthesis[Title/Abstract]) OR Prosthesis Implantation, Hip[Title/Abstract]) OR Prosthesis Implantations, Hip[Title/Abstract]) OR Hip Replacement Arthroplasty[Title/Abstract]) OR Replacement Arthroplasties, Hip[Title/Abstract]) OR Replacement Arthroplasty, Hip[Title/Abstract]) OR Arthroplasties, Hip Replacement[Title/Abstract]) OR Hip Replacement Arthroplasties[Title/Abstract]) OR Hip Replacement, Total[Title/Abstract]) OR Replacement, Total Hip[Title/Abstract]) OR Hip Replacements, Total[Title/Abstract]) OR Replacements, Total Hip[Title/Abstract]) OR Total Hip Replacements[Title/Abstract]) OR Total Hip Replacement[Title/Abstract])).

Eligibility criteria

(1) Participants: patients prepared for primary THA;

(2) Interventions: the intervention group received the DAA approach in THA surgery;

(3) Comparisons: the control group received PA approach in THA surgery;

(4) Outcomes: clinical outcomes such as length of incision, surgery time, length of stay, blood loss, and transfusion rates; complication such as dislocation, fracture, LCNT neuropraxia, DVT and overall complication; radiographic outcomes such as acetabular inclination and acetabular anteversion; functional outcomes such as VAS at 1day, 2 days, 12 months postoperative and Harris hip score at 6 weeks, 3 months, 6 months, 12 months.

(5) Study design: randomized controlled trials.

Study selection

We imported all the studies into Endnote X7 software (Thompson Reuters, CA, USA) based on the search strategy. Two reviewers (Linbo Peng and Junfeng Zeng) scanned the titles and abstracts independently, we resorted to senior reviewers for decision while a controversy existed. Eligible studies were RCTs compared DAA and PA approach in THA surgery. We excluded the literature that is published duplicated, commentaries, letters, cases, reviews, obvious irrelevant studies, minimally invasive, piriformis preserving approaches, computer-aided technology, and other surgical approaches. Then we read the full text to exclude other improper studies.

Data extraction

Two authors extracted the following information respectively and then reviewed together to guarantee data accurate: the name of first author, publication year, Study design, surgeon number, Cases number of each group, follow-up time, gender distribution, average age, BMI, learning cases, length of incision, surgery time, length of stay, blood loss and transfusion rates, dislocation, fracture, LCNT neuropraxia, DVT and overall complication, acetabular inclination and acetabular anteversion, VAS at 1day, 2 days, 12 months postoperative and Harris hip score at 6 weeks, 3 months, 6 months, 12 months.

Risk of bias in individual studies

Two authors respectively assessed the risk of bias for each article by the Cochrane Bias risk assessment tool. Disagreements were resolved by discussion with a senior researcher. We judge each study as low, high or unclear risk of bias in each domain.

Outcome measures and statistical analysis

We conduct this study by the Review Manager software 5.3. All the data are extracted into excel firstly and then divided into categorical variables and continuous variables. Categorical variables (transfusion rates, complications (such as dislocation, fracture, LCNT neuropraxia, DVT and overall complication)) were expressed as odds ratio (OR) with 95% CIs. Continuous variables (length of incision, surgery time, length of stay, blood loss, acetabular inclination, acetabular anteversion, VAS at 1day, 2

days, 12 months postoperative and Harris hip score at 6 weeks, 3 months, 6 months, 12 months) were expressed as the mean differences (MD) with 95% confidence intervals (CIs). We use a fixed effects model when there is no statistical heterogeneity among these literatures ($p > 0.1$, $I^2 < 50\%$), and a random effects model when heterogeneity exist ($p < 0.1$, $I^2 > 50\%$). otherwise, descriptive analysis was used. The results of the meta-analysis were shown in forest maps; We consider $p < 0.05$ as a statistically significant difference.

Results

Study selection

We initially obtained 969 studies and included 7 randomized controlled trials with 600 participants into the meta-analysis after screening for eligibility[18-20, 28-31]. The PRISMA study flow diagram is shown in Figure 1.

Study characteristics

A total of 7 randomized controlled trials with 600 participants were included. one study showed statistical significance in gender[28], one study did not state the BMI data[19]. All the studies were not learning cases, The demographic characteristics of patients are shown in Table 1.

Risk of bias

All the studies included in the meta-analysis were randomized controlled trials with high quality. It's hard to achieve blindness for doctors in surgery, but we think the detection bias outcome is unlikely to be affected by the absence of blindness. The risk of bias graph of each study and the risk of bias summary are shown in Figure 2 and figure 3.

Clinical outcomes

Length of incision

Five studies[18-20, 28, 31] with a total of 503 patients were eligible to compare the length of incision between DAA and PA in primary THA. We failed to find a significant difference between the DAA group and PA group with significant statistical heterogeneity among study groups (MD=-2.79 cm, 95%CI -5.77 to 0.18, $p = 0.07$, $I^2=100\%$, Fig. 4).

Surgery time

Six studies[18-20, 28, 30, 31] with a total of 549 patients were eligible to compare the surgery time between DAA and PA in primary THA. DAA inclined to a significantly longer surgery time (13.74 min, 6.88 to 20.61, $p<0.0001$, Fig.5), but there was significant statistical heterogeneity among the study groups($I^2=93\%$).

Blood loss

Four studies[20, 28, 30, 31] with a total of 357 patients were eligible to compare the perioperative blood loss between DAA and PA in primary THA. We failed to find a significant difference between the DAA group and PA group with significant statistical heterogeneity among study groups. (MD=58.96 ml, 95% CI -4.46 to 122.38, p = 0.07, I^2=97%, Fig. 6).

Transfusion rates

Three studies[19, 20, 31] with a total of 344 patients were eligible to compare the Transfusion rates between DAA and PA in primary THA. We failed to find a significant difference between the DAA group and PA group with significant statistical heterogeneity among study groups. (OR=0.35, 95%CI 0.04 to 3.15, p = 0.35, I^2=87%, Fig. 7).

Length of stay (LOS)

Six studies[18, 19, 28-31] with a total of 496 patients were eligible to compare the LOS between DAA and PA in primary THA. There was no significant difference between the DAA group and PA group in terms of the LOS (MD=-1.52 day, 95%CI -3.75 to 0.71, p = 0.18, Fig. 8). There was significant statistical heterogeneity among the study groups(I^2=100%).

Complication

Five studies[18-20, 28, 31] were eligible to compare the complication between DAA and PA in primary THA. Three studies[18, 20, 28] reported postoperative dislocation. And there was no significant difference between the two groups in terms of the dislocation (OR=0.52, 95%CI 0.09 to 3.08, p = 0.48, I^2=0%, Fig. 9). Three studies[18, 28, 31] reported postoperative fracture. And there was no significant difference between the two groups in terms of the fracture (OR=1.45, 95%CI 0.27 to 7.66, p = 0.67, I^2=0%, Fig. 10). Three studies[18-20] reported postoperative DVT. And there was no significant difference between the two groups in terms of DVT (OR=0.43, 95%CI 0.08 to 2.45, p = 0.34, I^2=0%, Fig. 11). Two studies[18, 20] reported postoperative LCNT neuropraxia. And there was no significant difference between the two groups in terms of LCNT neuropraxia (OR=43.20, 95%CI 0.70 to 2654.71, p = 0.07, I^2=74%, Fig. 12). Four studies[18-20, 28] reported overall postoperative complications. And there was no significant difference between the two groups in terms of overall postoperative complications (OR=1.39, 95%CI 0.72 to 2.66, p = 0.32, I^2=0%, Fig. 13).

Functional outcomes

VAS Score

Three studies[20, 28, 31] with a total of 311 patients were eligible to compare the VAS Score between DAA and PA in primary THA. There was no significant difference between the two groups in terms of the

preoperative VAS score (MD=-0.08, 95%CI -0.41 to 0.25, p = 0.62, I^2=42%, Fig.14). Two studies[28, 31] followed-up the VAS score postoperative 1 day and 2 days. DAA inclined to a significantly higher VAS Score postoperative 1 day (MD=-0.65, -0.91 to -0.38, p<0.00001, I^2=0%, Fig.15). DAA showed a significantly higher VAS Score postoperative 2 days (MD=-0.67, -1.34 to -0.01, p=0.05, I^2=88%, Fig.16), but there was significant statistical heterogeneity among the study groups(I^2=88%). Two studies[20, 28] followed-up the VAS score postoperative 12 months. There was no significant difference between the two groups in terms of the VAS score postoperative 12 months (MD=-0.01, 95%CI -0.47 to 0.50, p = 0.96, I^2=72%, Fig.17).

Harris Hip Score (HHS)

Five studies[19, 20, 28, 30, 31] with a total of 477 patients were eligible to compare the HHS Score between DAA and PA in primary THA. There was no significant difference between the two groups in terms of the preoperative HHS score (MD=-0.61, 95%CI -2.15 to 0.93, p = 0.44, I^2=12%, Fig.18). Two studies[28, 30] followed-up the HHS score postoperative 6 weeks. DAA inclined to a significantly higher HHS Score postoperative 6 weeks (MD=6.05, 1.14 to 10.95, p=0.02, I^2=52%, Fig.19). Three studies[19, 28, 31] followed-up the HHS score postoperative 3 months. There was no significant difference between the two groups in terms of the HHS score postoperative 3 months (MD=6.30, 95%CI -1.70 to 14.31, p = 0.12, I^2=89%, Fig.20). Two studies[28, 31] followed-up the HHS score postoperative 6 months. There was no significant difference between the two groups in terms of the HHS score postoperative 6 months (MD=0.67, 95%CI -1.87 to 3.21, p = 0.60, I^2=0%, Fig.21). Two studies[20, 28] followed-up the HHS score postoperative 12 months. There was no significant difference between the two groups in terms of the HHS score postoperative 12 months (MD=0.65, 95%CI -1.16 to 2.46, p = 0.48, I^2=0%, Fig.22).

Radiographic outcomes

According to the Lewinnek safe zone (anteversion angle of 15°±10° and abduction angle of 40° ±10°)[32], we estimated the radiographic outcomes of DAA and PA. Five studies[18-20, 28, 31] with a total of 503 patients were eligible to compare the radiographic outcomes between DAA and PA in primary THA. There was no significant difference between the two groups in terms of the preoperative anteversion angle (MD=-0.01, 95%CI -4.21 to 4.20, p = 1.00, I^2=96%, Fig.23). Besides, There was no significant difference between the two groups in terms of the preoperative abduction angle (MD=1.06, 95%CI -0.95 to 3.07, p = 0.30, I^2=82%, Fig.24).

Discussion

We performed this systematic review and meta-analysis of 7 randomized controlled trials with 600 participants comparing the DAA and PA in primary THA. In the comparison of clinical outcomes, we found that DAA was associated with a longer surgery time by a mean of 13.74 min (95% CI 6.88 to 20.61, p < 0.0001, I^2 = 93%). There was no significant difference between the DAA and PA groups at length of

incision, length of stay (LOS), blood loss, transfusion rates or complication rates. In the comparison of functional outcomes, early functional outcomes were significantly better in the DAA group than PA group such as Visual Analogue Scale (VAS) postoperative 1 day (MD=-0.65, 95% CI -0.91 to -0.38, $p < 0.00001$, $I^2 = 0\%$), VAS score postoperative 2 days (MD=-0.67, 95% CI -1.34 to -0.01, $p = 0.05$, $I^2 = 88\%$) and Harris Hip Score (HHS) postoperative 6 weeks(MD = 6.05, 95% CI 1.14 to 10.95, $p = 0.02$, $I^2 = 52\%$). There is no significant difference between the two groups about Late functional outcomes such as VAS score postoperative 12 months or HHS scores postoperative 3, 6, 12 months. The significant difference in Radiographic outcomes cannot be detected too. To authors' knowledge, This was the first meta-analysis of RCTs with direct-evidence who comprehensive compare the clinical, functional and radiographic outcomes of primary total hip arthroplasty between DAA and PA.

Compared with the meta-analysis published in the past, the highlight of our study was that we only included RCTs into the study and compared the clinical, functional and radiographic outcomes systematically, which provided Level I evidence of evidence-based medicine[33]. The meta-analysis of Miller et al[24] reported shorter length of incision, less pain in the hospital, less opioid medication needing and shorter LOS in the DAA group when compared with PA. But one study[34] in their meta-analysis compared the DAA and mini-posterior approach instead of conventional PA, which may aggravate the heterogeneity. Wang et al[25] reported shorter incision length and postoperative blood loss with a significant difference in the DAA group when compared with PA. They also found no significant difference in the operation time and complications between the two groups. But they included one non-randomized study and one retrospective study into the meta-analysis, which made the results untrustworthy. Jia et al[21] found shorter LOS and longer surgery time with a significant difference in the DAA group when compared with PA group. The authors also included a mini-posterior approach study, which may aggravate heterogeneity. In another meta-analysis of Miller et al[23], They reported that DAA was associated with a lower rate of infection, dislocation, and reoperation. But most of their studies were retrospective, which inevitably led to bias. The LCNT neuropraxia outcomes various among different studies and there were only two RCTs[18, 20] reported this kind of special complication in our study. Some other researchers[14, 21, 34] reported different LCNT neuropraxia outcomes in non-RCTs. We thought this kind of high heterogeneity may due to the different experiences of the surgeon. In our study, early functional outcomes such as VAS postoperative 1 day, VAS postoperative 2 days and HHS postoperative 6 weeks were significantly better in the DAA group than PA group. Some other studies[21, 22, 25] also found better early functional outcomes and fewer pain scores in the DAA group. Our findings proved this conclusion again and strengthen the level of evidence. Due to the lack of more effective data, we failed to explore the functional outcomes such as EQ5D, 6MWT, WOMAC and HOOS. In the comparison of radiographic outcomes, Jia et al[21] also found that there was little difference in prosthetic position between the two groups.

There was nearly no statistical significance about the demographic characteristics of patients in our meta-analysis. Besides, All the studies were not learning cases avoiding being influenced[35]. But there

was still a high heterogeneity among most outcomes. We considered this was mainly due to the difference between the surgeons and the hospital about the surgery approach. Lack of enough RCTs may be another important reason for the high heterogeneity.

This study has several limitations. Firstly, the number of RCTs included in the study was not enough, which might lead to inaccurate results. Secondly, some RCTs used unclear or high-risk allocation concealment and selective reporting, which may lead to the short of high quality. Thirdly, the information about complications is insufficient. Therefore, the complication outcomes were not credible enough. Finally, we failed to explore the intermediate stage functional outcomes because of lacking enough data.

Conclusion

DAA needs longer surgery time than PA in primary total hip arthroplasty. The DAA offers better early functional recovery than PA. There is no significant difference between the two groups in terms of other clinical, complication, late functional and radiographic outcomes. The evidence about the superiority of DAA is insufficient, which needs more research.

Abbreviations

RCTs, randomized controlled trials; DAA, direct anterior approach; PA, posterior approach; THA, total hip arthroplasty; VAS, visual analogue scale; MD, mean deviation; CI, confidence interval; HHS, harris hip score; LOS, length of stay; OA, osteoarthritis; PRISMA, preferred reporting items for systematic reviews and meta-analyses; LCNT, lateral cutaneous nerve of the thigh; USA, the united states of America; BMI, body mass index; OR, odd ratio; 6MWT, the 6-min walk test; WOMAC, the Western Ontario and McMaster Universities Osteoarthritis Index; HOOS, hip disability, and osteoarthritis outcome score; DVT, deep vein thrombosis.

Declarations

Ethics approval and consent to participate

Ethical approval is not necessary because it is a review study of previous RCTs, and we did not get any other data from patients. The consent to participate is not applicable.

Consent for publication

Not applicable.

Availability of data and material

All data and materials are contained within the manuscript.

Competing interests

Author Linbo Peng, Author Yi Zeng, Author Yuangang Wu, Author Junfeng Zeng, Author Yuan Liu, and Author Bin Shen declare that they have no conflict of interest.

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Authors' contributions

The following authors designed the study (BS), gathered the data (LBP, JFZ), analyzed the data (LBP, YL), wrote the initial drafts (LBP), and ensured the accuracy of the data and analysis (BS, YZ, YGW). All Authors read and approved the manuscript.

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All authors agree with the publication of this study.

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Table 1

Table 1.

Study	Year	Study design	Surgeon Number	follow-up time	Cases DAA:PA	ages DAA:PA	male/female DAA:PA	BMI DAA:PA	learning cases
Barrett	2013	RCT	1	12 months	43:44	61.4 ± 9.2: 63.2 ± 7.7	29/14: 19/25	30.7±5.4:29.1±5.0 27.7 28.3	NO
Cheng	2016	RCT	2	12 weeks	35:37	59 : 62.5	15/20: 18/20	31.1±5.1:30.4±3.6 22.7±4.4:24.2±3.7	NO
Christensen	2015	RCT	1	6weeks	28:23	64.3±9.1:65.2±9.1	13/15: 11/12	29.0±5.6:29.3±4.8 not stated	NO
Luo	2016	RCT	1	16 months	52:52	61.5±7.2:63.7±6.8	17/35: 22/30 8/15: 11/12 25/35: 28/32 24/36: 26/34	24.3±53.1:25.58±2.83	NO
Rykov	2017	RCT	3	6 weeks	23:23	62.8±6.1 60.2±8.1			NO
Zhang	2006	RCT	Not clear	30months	60:60	61: 62.5			NO
Zhao	2017	RCT	Not clear	6 months	60:60	64.88±12.13:62.18±14.72			NO

Figures

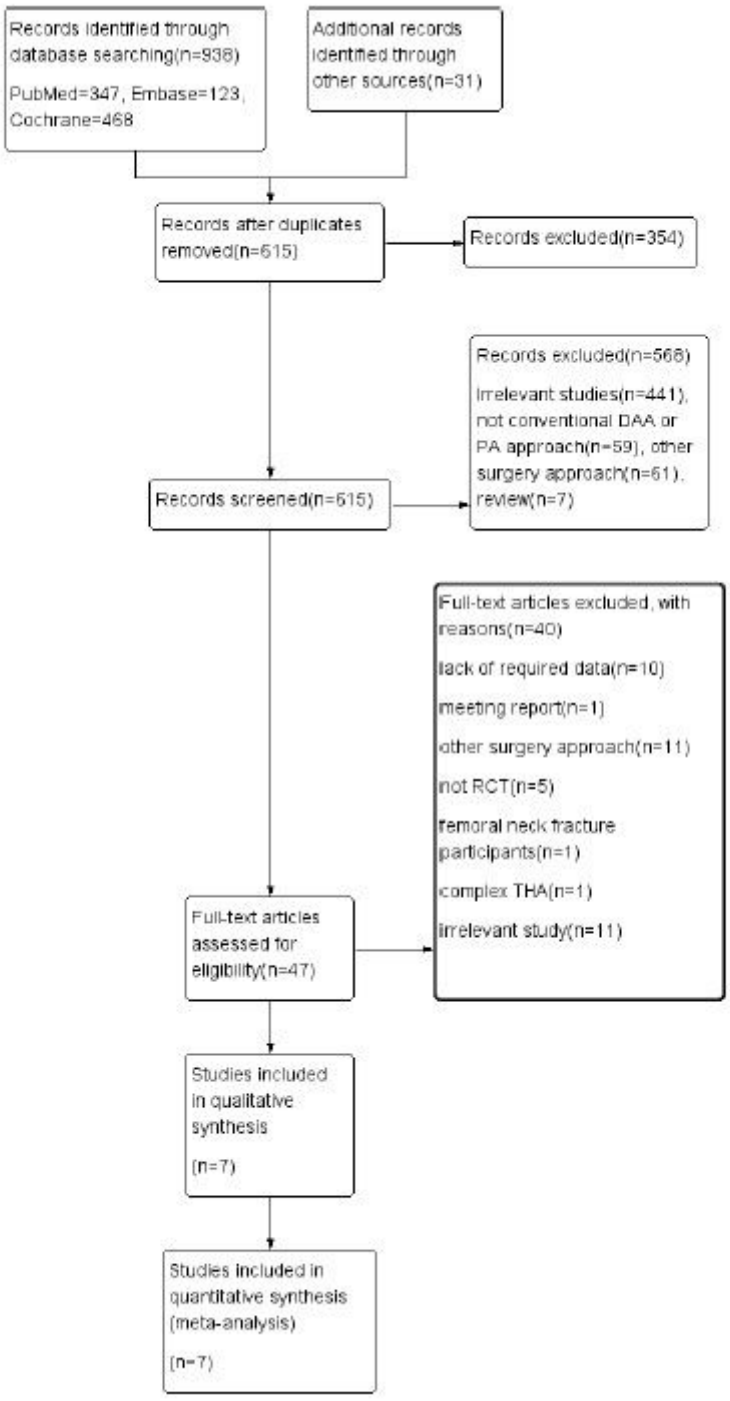

Figure 1

PRISMA study flow diagram

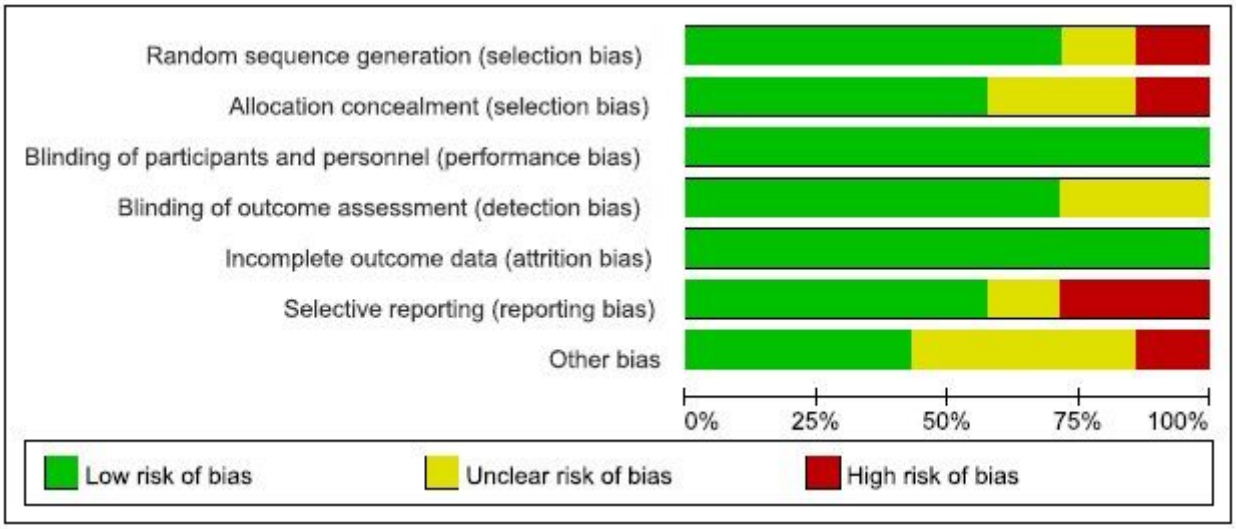

Figure 2

Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

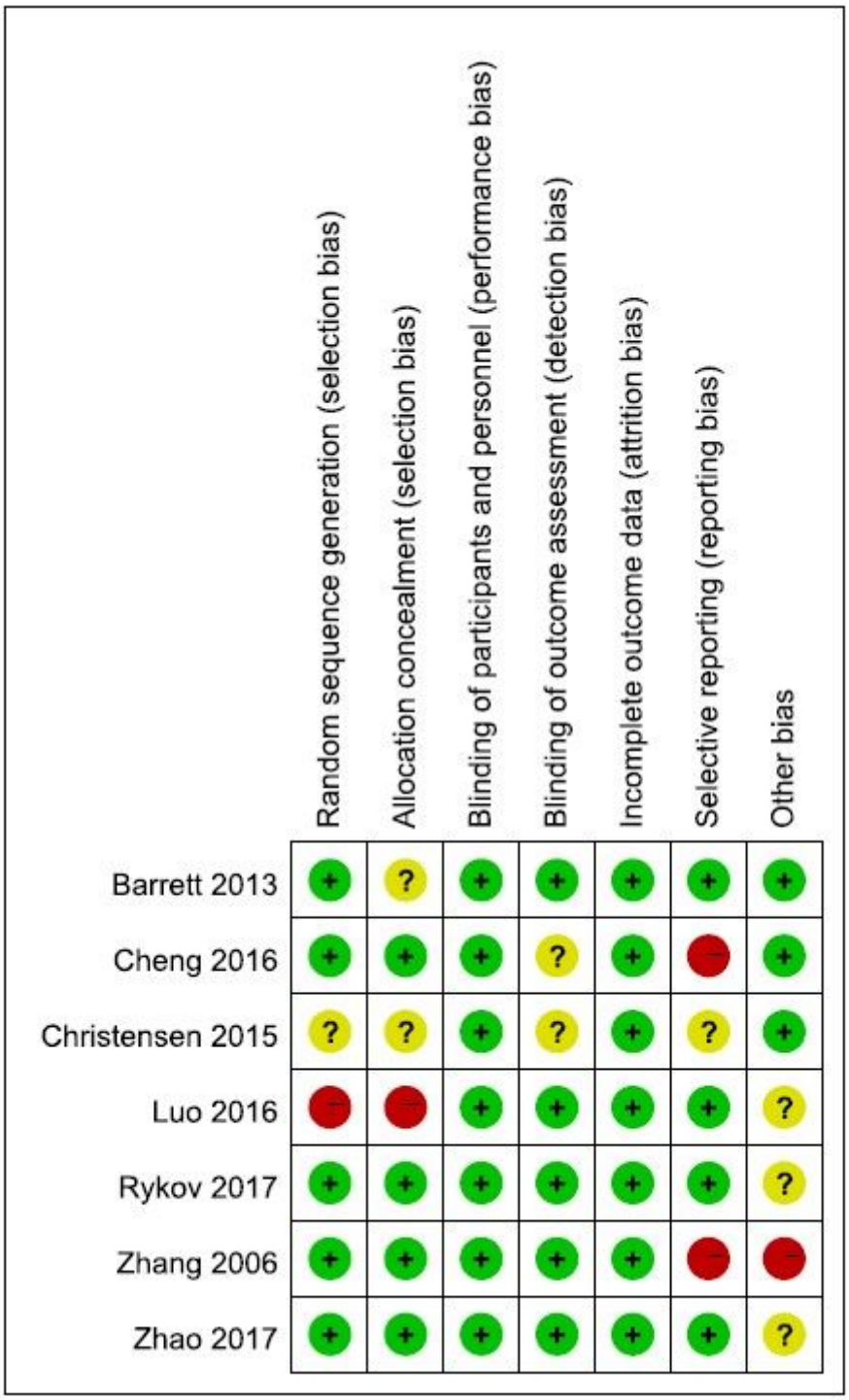

Figure 3

Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

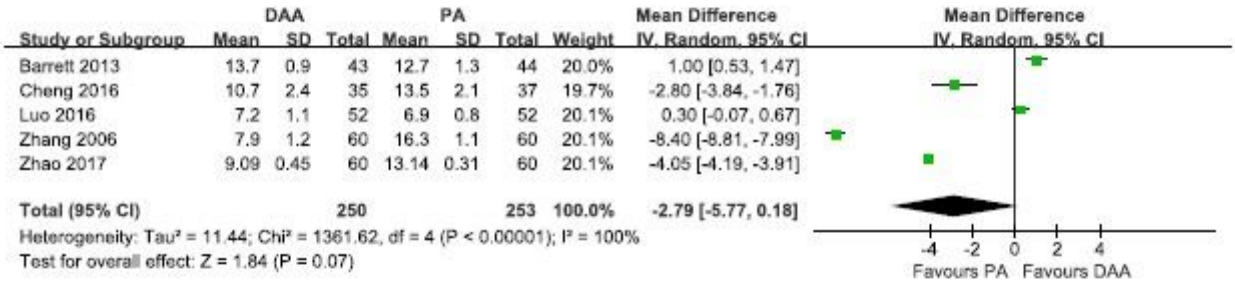

Figure 4

Length of incision (cm) forest plot analysis with DAA vs PA in primary THA

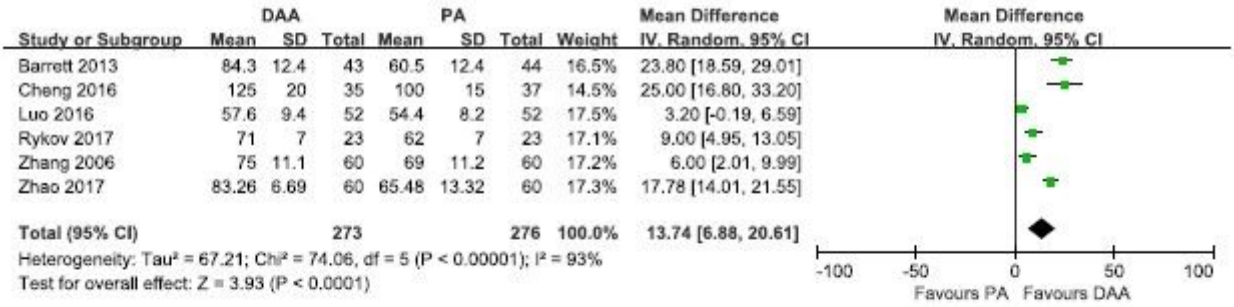

Figure 5

Surgery time (min) forest plot analysis with DAA vs PA in primary THA

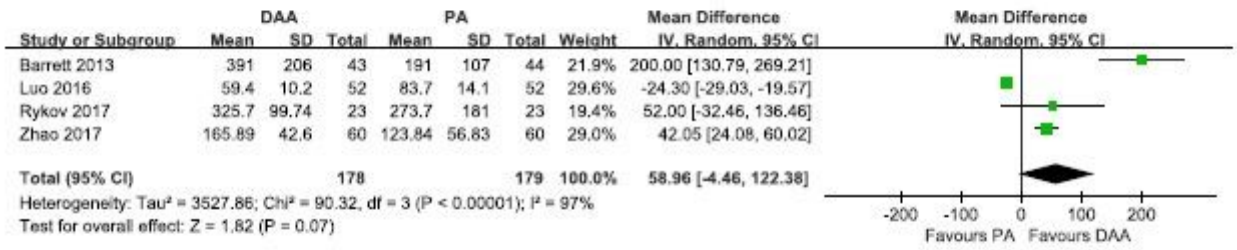

Figure 6

Blood loss (ml) forest plot analysis with DAA vs PA in primary THA

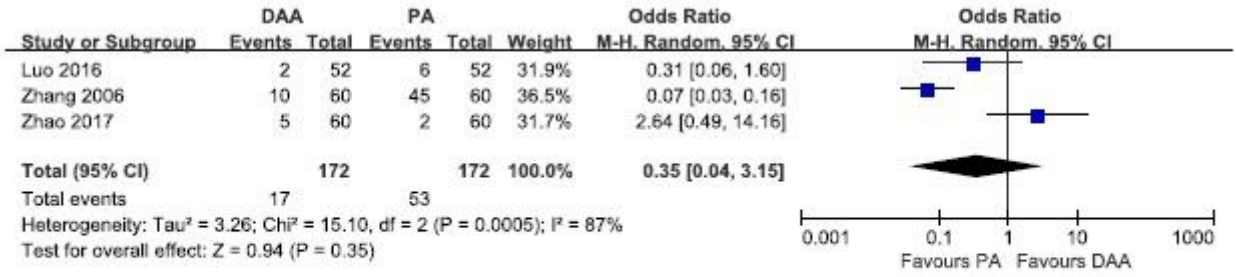

Figure 7

Transfusion rates forest plot analysis with DAA vs PA in primary THA

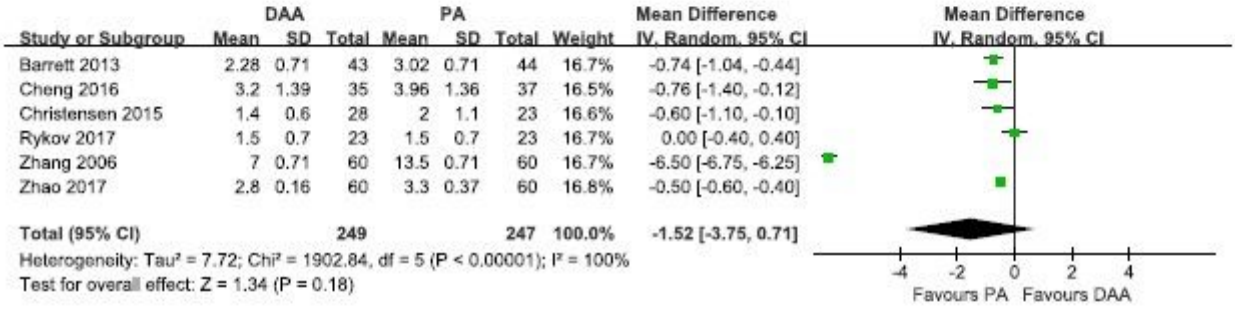

Figure 8

Length of stay forest plot analysis with DAA vs PA in primary THA

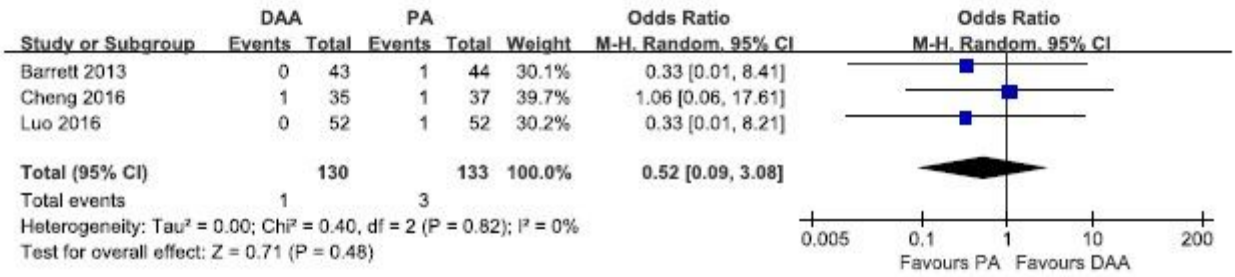

Figure 9

Postoperative dislocation forest plot analysis with DAA vs PA in primary THA

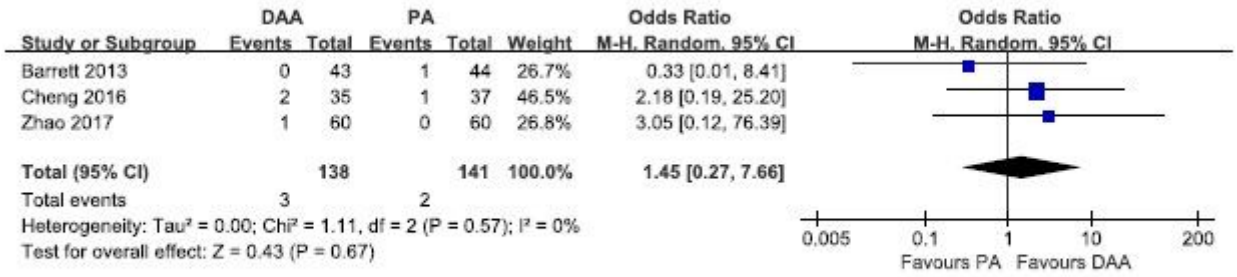

Figure 10

Postoperative fracture forest plot analysis with DAA vs PA in primary THA

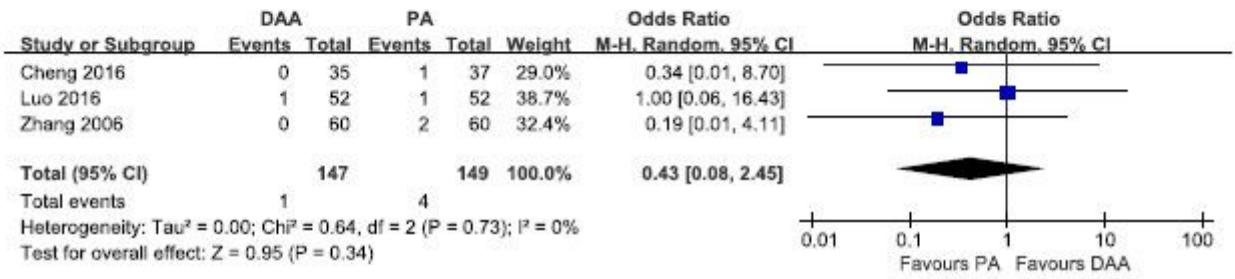

Figure 11

Postoperative DVT forest plot analysis with DAA vs PA in primary THA

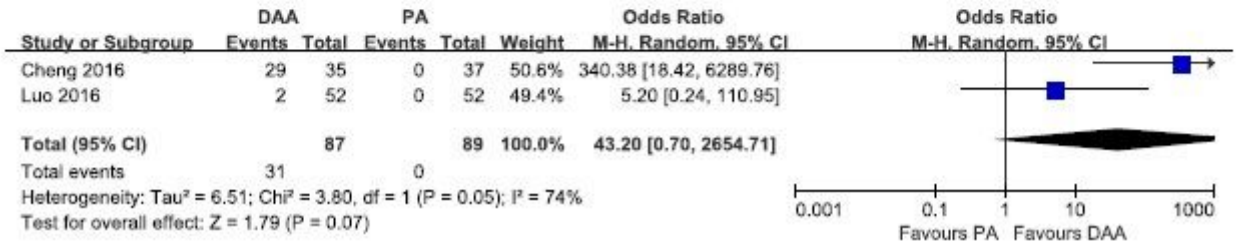

Figure 12

Postoperative LCNT neuropraxia forest plot analysis with DAA vs PA in primary THA

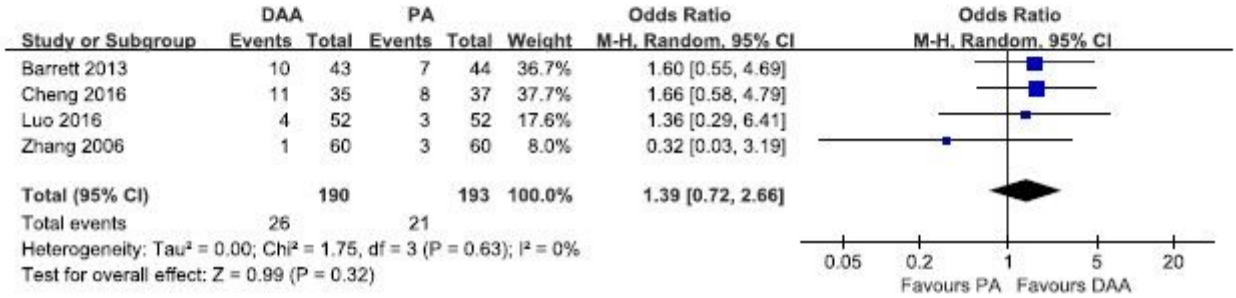

Figure 13

Postoperative overall complication forest plot analysis with DAA vs PA in primary THA

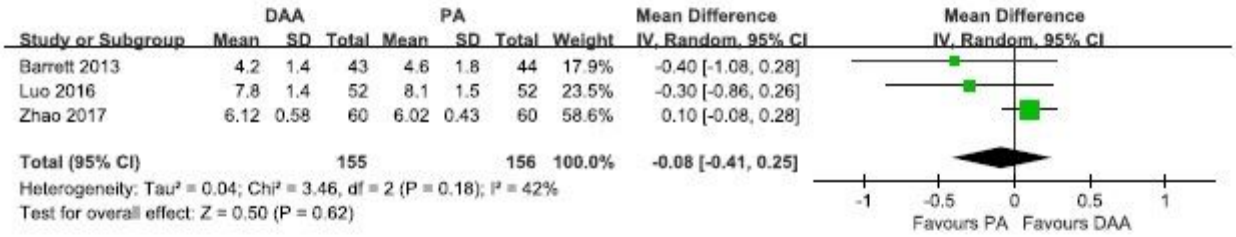

Figure 14

Preoperative VAS score forest plot analysis with DAA vs PA in primary THA

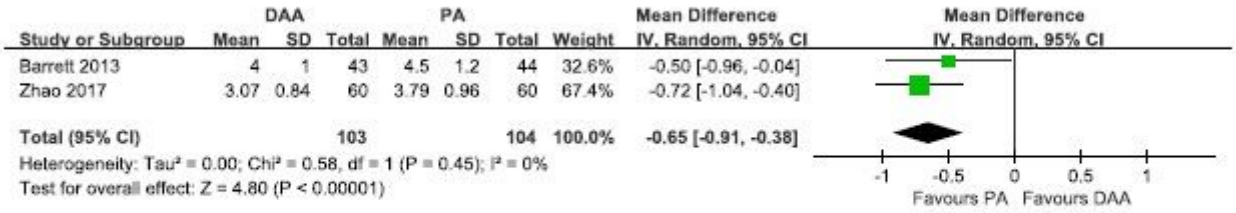

Figure 15

VAS score postoperative 1 day forest plot analysis with DAA vs PA in primary THA

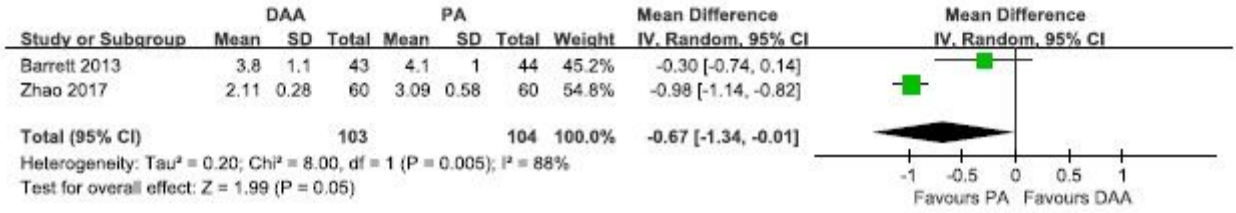

Figure 16

VAS score postoperative 2 day forest plot analysis with DAA vs PA in primary THA

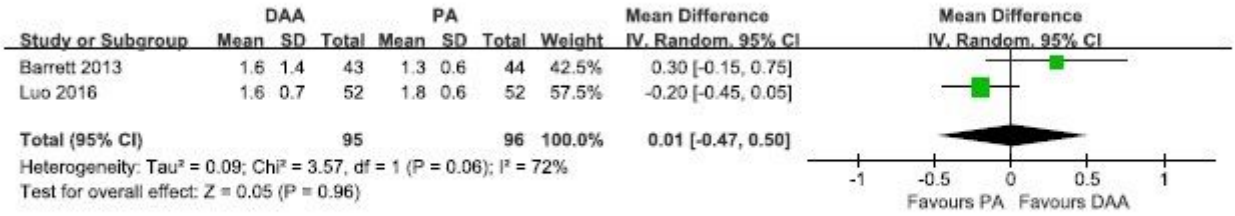

Figure 17

VAS score postoperative 12 months forest plot analysis with DAA vs PA in primary THA

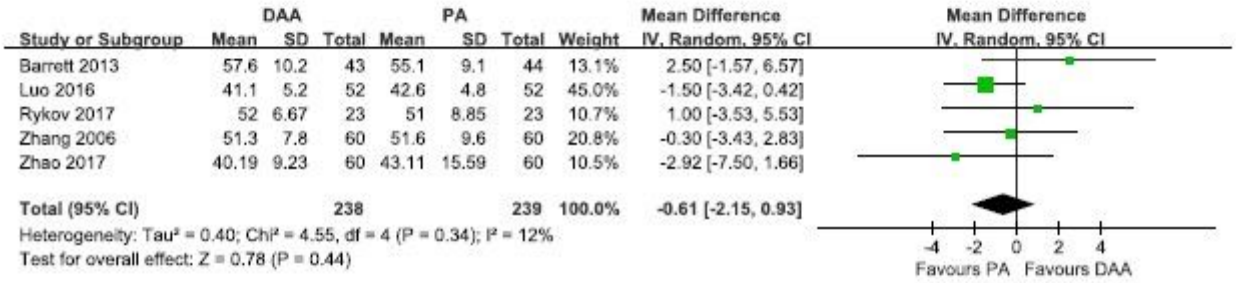

Figure 18

Preoperative HHS score forest plot analysis with DAA vs PA in primary THA

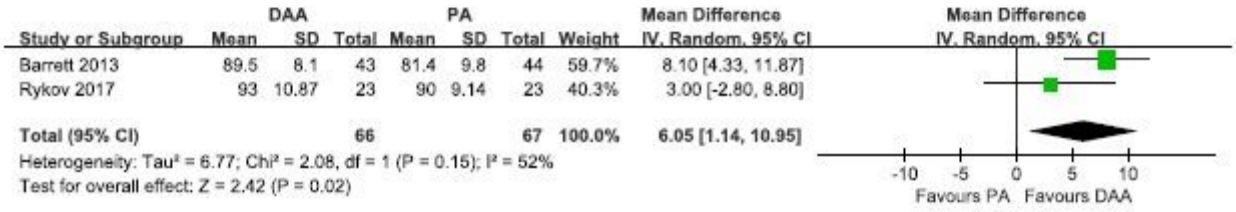

Figure 19

HHS score postoperative 6 weeks forest plot analysis with DAA vs PA in primary THA

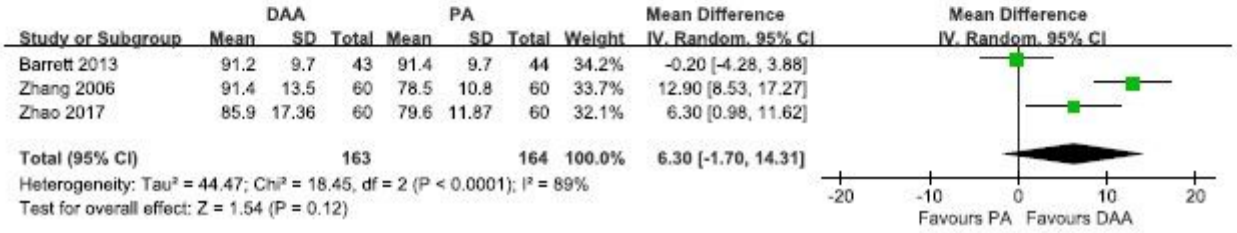

Figure 20

HHS score postoperative 3 months forest plot analysis with DAA vs PA in primary THA

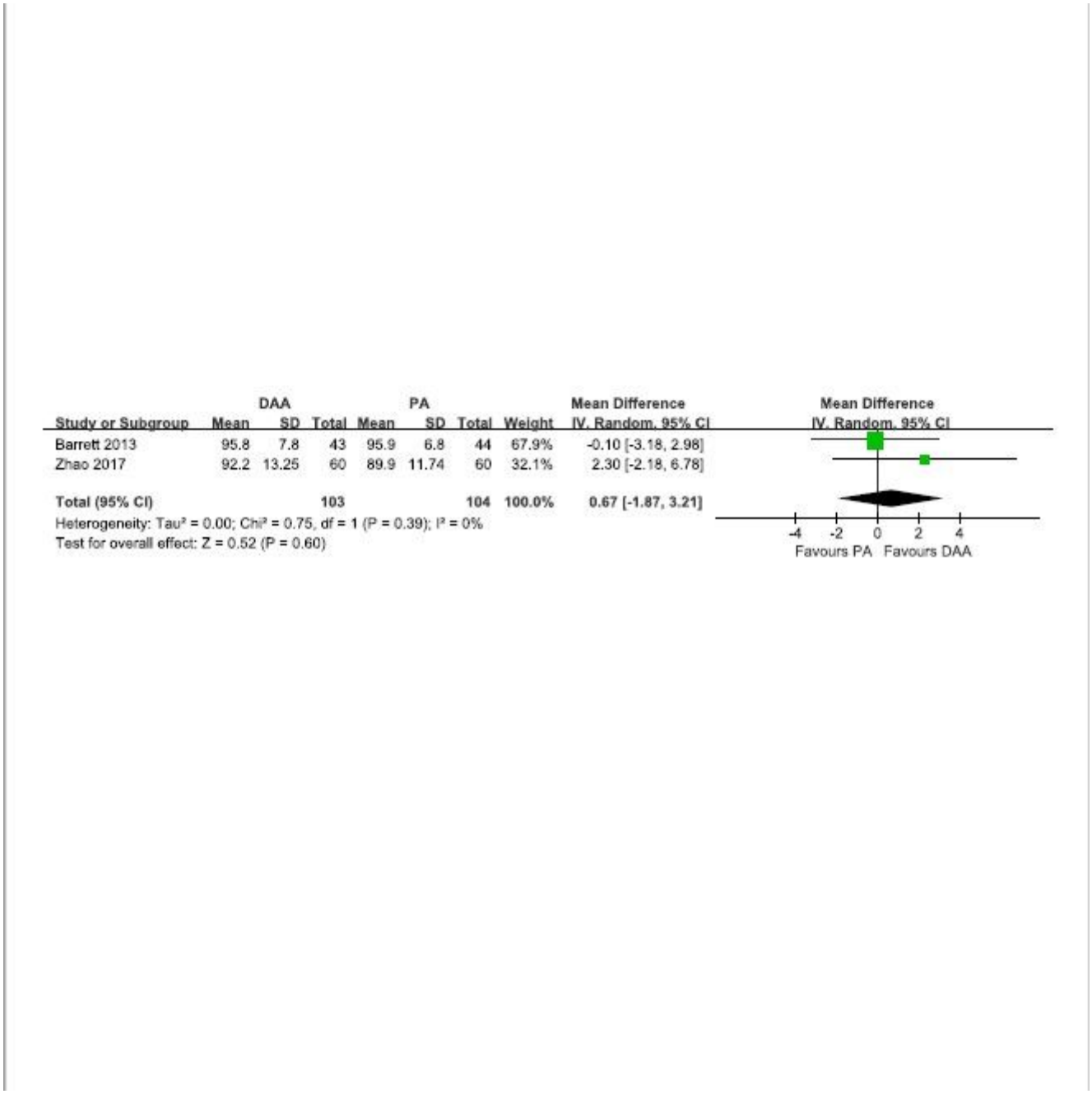

Figure 21

HHS score postoperative 6 months forest plot analysis with DAA vs PA in primary THA

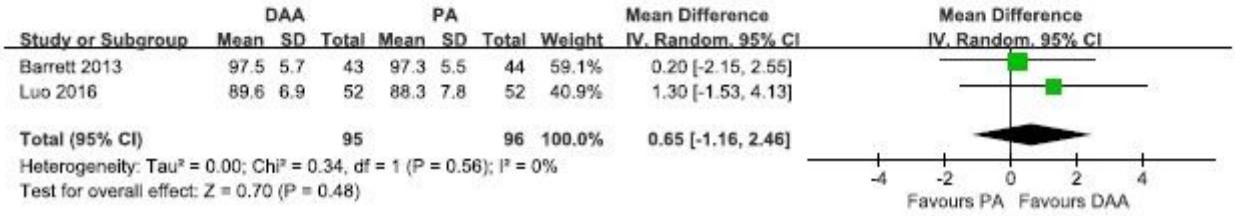

Figure 22

HHS score postoperative 12 months forest plot analysis with DAA vs PA in primary THA

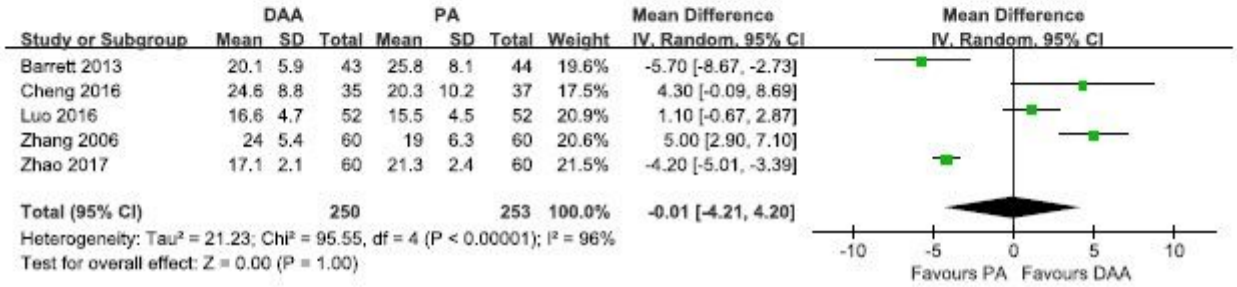

Figure 23

Postoperative anteversion angle forest plot analysis with DAA vs PA in primary THA

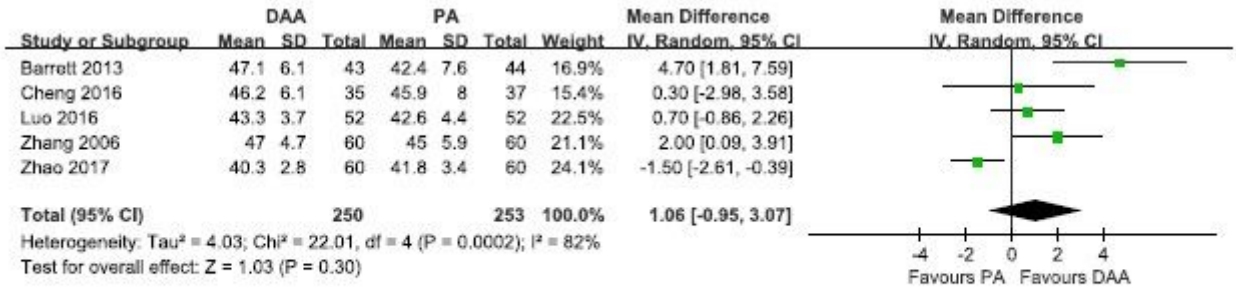

Figure 24

Postoperative abduction angle forest plot analysis with DAA vs PA in primary THA

Supplementary Files

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- PRISMAchecklist.doc