

A systematic review and meta-analysis of SuperPATH approach in hip arthroplasty

Yanzhi Ge

Zhejiang Chinese Medical University <https://orcid.org/0000-0002-3666-5835>

Li Zhou

Zhejiang Chinese Medical University

Zuxiang Chen

Zhejiang Chinese Medical University

Ting Li

Zhejiang University

Peijian Tong

Zhejiang Chinese Medical University

Letian Shan (✉ letian.shan@zcmu.edu.cn)

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Abstract

Background: To compare the clinical and radiographic results of supercapsular percutaneously assisted total hip (SuperPATH) approach and conventional approach by systematic review and meta-analysis.

Methods: Based on a pre-published protocol (PROSPERO CRD42020177717), we systematically retrieved databases from Pubmed, Embase, Cochrane and Web of Knowledge for relevant literatures from the earliest available date to May 30, 2020. No language restriction was applied. RevMan 5.3 software was used to perform the meta-analysis. The methodological qualities were assessed using the guidelines provided by the Cochrane Collaboration for Systematic Reviews. Two reviewers were independently extracted data from all eligible studies, including types of studies, participants, interventions, and outcomes. Randomized or fixed-effect models were used to calculate the weighted mean difference (WMD), odds ratio (OR) for continuous and dichotomous variables, respectively.

Results: 6 articles were included in the study and 526 patients were selected, which was including 233 cases in the SuperPATH groups, 279 cases in the conventional groups and 4 cases performed two surgeries in succession. The SuperPATH group demonstrated shorter incision length (WMD = - 7.87, 95 % CI - 10.05 to - 5.69, $P < 0.00001$), decreased blood transfusion rate (OR = 0.48, 95 % CI 0.25 to 0.89, $P = 0.02$), decreased visual analogue scale (VAS) (WMD = -0.40, 95 % CI - 0.72 to - 0.08, $P = 0.03$) and higher Harris hip score (HHS) (WMD = 1.98, 95 % CI 0.18 to 3.77, $P = 0.0002$) than those in the conventional group. However, there was no difference in VAS and HHS between the two groups half a year later. There was no significant difference in the acetabular abduction angle (WMD = - 1.32, $P = 0.32$) in either group.

Conclusions: SuperPATH minimally invasive approach with its reduced tissue damage, quick postoperative recovery and early rehabilitation demonstrates the short-term advantages of hip arthroplasty. However, the evidence for SuperPATH technique was limited in the number of studies and short duration of follow-up, so long-term results still need further analysis.

Background

Hip arthroplasty is an effective method of treatment for various hip disease. Due to its ability to relieve pain effectively, early mobilization and improving patients' life quality, hip arthroplasty is increasingly favored by surgeons. In recent years, artificial joint replacement and surgical instruments had ameliorated rapidly. As minimally invasive surgery technology develops, it had improved the surgical results and reduced the possibility of surgical injury. More and more minimally invasive approaches were being proposed and developed, and minimally invasive technique was the trend of future [1–3].

Supercapsular percutaneously assisted total hip (SuperPATH) technology was first reported by Professor James Chow in 2011 [4]. The approach ran between the gluteus minimus and piriformis, without cutting off any hip muscles, preserving the integrity of muscles around the joint capsule [4, 5]. With the advantages of being minimally invasive, SuperPATH was conducive to rapid rehabilitation for patients after surgery. Compared with the conventional approach, SuperPATH technology gained surgeons' praise for its small surgical incision, less soft tissue damage and fast postoperative rehabilitation. However, Rasuliet KJ et al [6] reported that SuperPATH had a longer learning curve and the approach plateaued at the 50th patient, which in some ways resulted in prolonged operation time.

To compare the SuperPATH approach with the conventional approach for hip arthroplasty, many RCTs and CCTs were performed. Therefore, we conducted this meta-analysis to explore short-term curative outcomes of the SuperPATH approach.

Methods

Protocol and registration

Literatures selection, assessments of eligibility criteria, data extraction and analyses were performed based on a protocol that was registered in PROSPERO: <https://www.crd.york.ac.uk/prospero/> (PROSPERO: CRD42020177717).

Literatures search strategies

A computerized retrieval of relevant literatures from Pubmed, Embase and Cochrane library were performed from their inception to May 30, 2020. All aspects of the international systematic review were followed using the Cochrane handbook and the study was written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [7]. Using the keywords and MeSH search strategy, the Pubmed search method was shown in Fig. 1.

Inclusion criteria

- (1) Population: Degenerative hip arthritis, avascular necrosis of the femoral head or fresh femoral neck fractures.
- (2) Interventions: SuperPATH approach or conventional approach.
- (3) Types of studies: randomized controlled trial (RCT), prospective or retrospective comparative study.
- (4) Types of outcomes: skin-to-skin operation time, length of incision, blood loss, blood transfusion rate, hospitalization time, visual analogue score (VAS), Harris hip score (HHS) and imaging measurements (acetabular anteversion angle and acetabular abduction angle). At least one of these items was reported.

Exclusion criteria

Patients were removed for any of the following conditions: (1) Revision of artificial total hip joint, severe osteoporosis, bone tumors, muscles or nervous system diseases. (2) No comparison of two approaches. (3) Follow-up period less than a year. (4) Republished literature, case reports and reviews.

Data extraction and quality assessment

Two reviewers were independently in accordance with the inclusion criteria for the quality of the literature evaluation and data extraction and then cross-checked. If there were any disagreements between them, a senior (Peijian Tong) would make a decision. The randomized controlled trials (RCTs) were evaluated for quality using the Cochrane risk assessment tool [8]. The Newcastle-Ottawa Scale (NOS) [9] was used for the quality assessment of cohort studies. This scale includes three major parts, such as the selection of study groups, ascertainment of exposure and outcome as well as group comparability. The general scores greater than or equal to 7 were considered low risk of bias.

The following information was extracted from the study: (1) Characteristics of the studies (author, published time, disease, surgery, type of study, case characteristics, etc.). (2) Outcome indicators: skin-to-skin operation time, length of incision, blood loss, blood transfusion rate, hospitalization time, imaging measurements (acetabular anteversion angle and acetabular abduction angle), postoperative VAS and HHS at 1 week, 1 month, 3 months and 6 months and 1 year after surgery.

Statistical methods

Meta-analysis was performed using the Revman5.3 (Cochrane Collaboration, Copenhagen, Denmark) software for the available indicators. For the dichotomous variable, the ORs (odds ratios) and 95% CI (confidence interval) were used as the effect indicators. For the continuous variables, the WMD (weighted mean difference) and 95%CI were used as the effect indicator. When statistical heterogeneity of study did not exist ($P \geq 0.1$ or $I^2 \leq 50\%$), the fixed-effects model was used. When statistical heterogeneity existed ($P < 0.1$ or $I^2 > 50\%$), the random-effects model was used for data synthesis. The results of this meta-analysis were shown in the forest-plot, and $P < 0.05$ was considered as statistically significant.

Results

Literature search results

A total of 392 articles were initially found and 127 articles were excluded for repeated publishing. By reading titles and abstracts, 239 pieces of literature were excluded from reviews, case reports and irrelevant studies. For no comparison of two approaches and literature that was not related to the purpose of the study, 8 documents were screened out. To further read the full text, we found a lack of required data in 9 pieces of literature and 3 pieces of literature included other irrelevant interventions. Finally, 6 articles [10–15] were selected. The PRISMA literature inclusion and exclusion process were shown in Fig. 2.

The basic characteristics and quality evaluation of included studies

The basic characteristics of the 526 patients were shown in Table 1. Concerning the body mass index, one of the study [15] was not mentioned. Regarding RCTs, there were a total of 3 studies [10, 11, 15] that were enrolled in this article. Due to the particularity of surgery, all of these three studies did not report the methods of binding to participants and/or operators. Besides, one paper[10] explained the randomization but no randomized paired design was mentioned. None of the 3 RCTs had a deficiency of being incomplete outcome or existing detection bias. The risk of bias graph and summary for these 3 studies were all shown in Figs. 3 and 4. As shown in Table 2, the NOS scores of these three cohort studies [12–14] were 8, 8 and 8, respectively. In general, all of the 6 articles included in this study were of good quality, with standardized research design and good research value. The number of studies enrolled was less than 10 and therefore no publication bias was conducted.

Table 1
Characteristics of the Included Study

| Study | Disease | Surgery | Type of study | Sex(F/M) | | Age (years) | | BMI(kg/m ²) | | Follow up (m) |
|---------------|-----------------------------------|----------------------|---------------|-----------------|--------------------|-----------------|--------------------|-------------------------|--------------------|---------------|
| | | | | SuperPATH group | Conventional group | SuperPATH group | Conventional group | SuperPATH group | Conventional group | |
| Xie 2017 | Hip osteoarthritis | THA | RCT | 12/34 | 19/27 | 66.6 ± 11.88 | 64.47 ± 12.09 | 23.62 ± 1.63 | 24.06 ± 2.72 | 12 |
| Xu 2019 | Femoral neck fractures | Hip hemiarthroplasty | CCT | 33/19 | 53/25 | 80.8 ± 4.4 | 80 ± 7.7 | 36.6 ± 4.4 | 36.0 ± 6.3 | 12 |
| Wang 2019 | Femoral neck fractures | THA | RCT | 28/27 | 30/25 | 69.03 ± 3.01 | 70.13 ± 3.35 | NS | NS | 12 |
| Martínez 2019 | Hip arthrosis | THA | CCT | 10/20 | 20/40 | 56.0 ± 14.2 | 60.0 ± 8.6 | 27.5 ± 4.8 | 27.9 ± 4.1 | 12 |
| Jia 2019 | Femoral neck fractures | Hip hemiarthroplasty | RCT | 19/31 | 21/29 | 78.1 ± 2.3 | 79.5 ± 2.6 | 23.82 ± 1.53 | 24.06 ± 1.72 | 12 |
| Meng 2019 | Osteonecrosis of the femoral head | Bilateral THA | CCT | 4/0 | | 51.0 ± 4.54 | | 21.49 ± 1.73 | | 12 |

SuperPATH supercapsular percutaneously assisted total hip, *BMI* Body mass index, *THA* Total hip arthroplasty, *RCT* Randomized controlled trial, *CCT* Case-controlled trial, *NS* Not state

Table 2
Newcastle-Ottawa Scale for Risk of Bias Assessment of Cohort Studies Included in the Meta-Analysis

| Study | Selection | | Comparability | | | Outcome | | | Overall |
|----------------|-----------|---|---------------|---|----|---------|---|---|---------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Martínez et al | □ | □ | □ | □ | □□ | □ | □ | □ | 8 |
| Xu et al | □ | □ | □ | □ | □□ | □ | □ | □ | 8 |
| Meng et al. | □ | □ | □ | □ | □□ | □ | □ | □ | 8 |

1 Representativeness of exposed cohort, 2 Selection of nonexposed, 3 Ascertainment of exposure, 4 Outcome not present at start, 5 Assessment of outcome, 6 Adequate follow-up length, 7 Adequacy of follow-up □ score of 0, □ score of 1, □□ score of 2

Primary outcomes

Operation time

Operation time (Fig. 5) was recorded in 6 studies [10–15] and random effects models were used because of the statistical heterogeneity of the results ($\text{Chi}^2 = 44.29$, $\text{df} = 5$, $I^2 = 89\%$, $p < 0.00001$). The results showed that there was no significant difference between two groups (WMD = 6.81, 95% CI - 1.47 to 15.09, $p = 0.11$).

Incision length

Based on the available datum from 4 studies [10, 11, 14, 15], we found significant heterogeneity ($\text{Chi}^2 = 111.20$, $\text{df} = 3$, $I^2 = 97\%$, $p < 0.00001$). As was shown in Fig. 6, the pooled results were statistically different between two groups based on the random effects model (WMD = -7.87, 95% CI - 10.05 to - 5.69, $p < 0.00001$).

Intraoperative blood loss

6 studies [10–15] recorded intraoperative blood loss. Because of statistical heterogeneity ($\text{Chi}^2 = 402.99$, $\text{df} = 5$, $I^2 = 99\%$, $p < 0.00001$), random effects models were applied. The results in Fig. 7 showed no significant difference between two groups (WMD = 41.74, 95% CI - 53.22 to 136.70, $p = 0.39$).

Blood transfusion rate

Data extracted from 4 studies [10, 11, 13, 14], including 326 participants, showed post-operative transfusion rate (Fig. 8). Due to no significant differences in heterogeneity ($\text{Chi}^2 = 2.05$, $\text{df} = 2$, $I^2 = 2\%$, $p = 0.36$), data was summarized using the fixed-effects model. The pooled results showed statistically significant difference between two groups (OR = 0.48, 95% CI 0.25 to 0.89, $p = 0.01$).

Hospitalization time

A total of 206 participants (Fig. 9) referred to the length of stay [10, 14, 15]. Due to no significant differences in heterogeneity ($\text{Chi}^2 = 45.28$, $\text{df} = 2$, $I^2 = 96\%$, $p < 0.00001$), data was summarized using random effects models. The pooled results showed no statistically significant difference between two groups (WMD = -1.94, 95% CI - 4.69 to 0.82, $p = 0.17$).

Acetabular anteversion angle and acetabular abduction angle

As was shown in Fig. 10, two studies [10, 14] showed significant heterogeneity of acetabular anteversion angle. The fixed effects model were adopted ($\text{Chi}^2 = 1.70$, $\text{df} = 1$, $I^2 = 41\%$, $p = 0.19$). There was significant difference between two groups (WMD = - 0.98, 95% CI - 1.6 to - 0.31, $p = 0.004$).

As was shown in Fig. 11, the results of two studies [10, 14] showed no statistically significant heterogeneity in acetabular abduction angle ($\text{Chi}^2 = 1.06$, $\text{df} = 1$, $I^2 = 6\%$, $p = 0.30$). The difference between two groups was no statistically significant (WMD = - 1.32, 95% CI - 3.92 to 1.27, $p = 0.32$).

VAS

Four articles [10, 11, 14, 15] mentioned VAS (Fig. 12). We found significant heterogeneity in pooled results, so we used the random-effect model ($\text{Chi}^2 = 282.54$, $\text{df} = 13$, $I^2 = 95\%$, $p < 0.00001$). The pooled follow-up results showed statistically significant difference between two groups (WMD = - 0.40, 95% CI - 0.72 to - 0.08, $p = 0.02$).

The subgroup analysis of VAS at 1 week and 1, 3, 6, 12 months after operation showed that week 1 (WMD = - 1.33, 95% CI - 2.16 to - 0.51, $p = 0.02$) was statistically significant, but indicated no statistical significance at one month (WMD = - 0.46, 95% CI - 1.12 to 0.20, $p = 0.17$), three months (WMD = - 0.17, 95% CI - 0.41 to 0.06, $p = 0.14$), six months (WMD = - 0.05, 95% CI - 0.23 to 0.14, $p = 0.62$), a year (WMD = - 0.09, 95% CI - 0.21 to 0.02, $p = 0.12$) after surgery.

HHS

As was shown in Fig. 13, the statistical analysis of 5 studies [10–12, 14, 15] showed statistically significant heterogeneity ($\text{Chi}^2 = 368.59$, $\text{df} = 16$, $I^2 = 96\%$, $p < 0.00001$). The difference of pooled follow-up results between two groups was statistically significant (WMD = 1.98, 95% CI 0.18 to 3.77, $p = 0.03$).

The meta-analysis of HHS showed that two groups at 1 week after surgery (WMD = 7.96, 95% CI 3.63 to 12.28, $p = 0.0003$), 1 month after operation (WMD = 3.76, 95% CI 2.09 to 5.42, $p < 0.00001$) and a year after operation (WMD = 0.84, 95% CI 0.17 to 1.51, $p = 0.01$) were significance respectively, but indicated no statistical significance at three months (WMD = -0.33, 95% CI -4.15 to 3.49, $p = 0.86$) and six months (WMD = -0.09, 95% CI -1.73 to 1.55, $p = 0.91$) after surgery.

Discussion

Early surgical intervention was often considered as the preferred choice for the treatment of a variety of hip diseases. Not only for rehabilitating earlier, but also for reducing the risk of various serious complications of being prolonged bed rest [16, 17]. With the continuous development of minimally invasive techniques, the patients' needs for rapid rehabilitation put considerable pressure on surgeons and other health care professionals. Consequently, we achieved excellent results in early functional recovery and short hospital stays [18]. Based on the evidence, Ibrahim MS et al [19] pointed out that minimally invasive surgery and fast-track arthroplasty units can be used to achieve rapid recovery, reduce hospital stays and improve functional outcomes after total hip arthroplasty (THA). THA raised the possibility of improving the clinical outcome and reducing surgical injury [20–22]. Patients were also more inclined to accept minimally invasive surgery.

SuperPATH technology was pioneered by Dr. James Chow of St. Luke's Medical Center in Phoenix, USA [2]. This technique combined Dr. Stephen Murphy's Supercap (MicroPort Orthopedics Inc., Arlington, TN, USA) technique [4] with Dr. Brad Penenberg's PATH (MicroPort Orthopedics Inc., Arlington, TN, USA) technique [23], which was a revolutionary technology to achieve a real minimally invasive. This approach was consistent with the anatomical landmarks of the conventional posterolateral approach, preserving all the advantages of the standard posterolateral approach, and special operative tables were no longer required. What's more, it can be easily converted to a standard posterior approach. In the process of soft tissue separation, SuperPATH technology did not transversely cut off muscles and tendons, preserving the integrity of the external rotators around the joint capsule. Furthermore, acetabular preparation can be easily done with the aid of the other percutaneous incision, thus providing rapid postoperative recovery with its intact muscles. Consequently, patients who underwent SuperPATH acquired faster recovery of postoperative activities.

This was the first systematic review and meta-analysis that comparing SuperPATH approach and conventional approach in hip arthroplasty. The result showed that 6 studies (two RCTs and 4 CCTs) met inclusion criteria for this systematic review and meta-analysis. In terms of incision length, all 4 studies showed that the average length of the surgical incision in the SuperPATH group was shorter than that in the conventional group. Also, compared with the greater trauma of the conventional approach, minimally invasive surgery cannot be defined by short incision solely. For instance, direct anterior access may injure the lateral femoral cutaneous nerve [24]; lateral approach may injure the superior gluteal nerve and cut off the insertion of gluteus minimus [25]; the posterior lateral approach needed to cut the piriformis muscle and then expose joint capsule [26]. In terms of minimally invasive surgery, the SuperPATH technology was a true minimally invasive technique. Not only for its minimal incision but also for protecting the external muscles and ligaments by means of not cutting them off. As we violently pull distal or proximal soft tissue during the process of surgery, there was a possibility of reducing postoperative incision necrosis, subcutaneous fat liquefaction and other complications for the other minimally invasive THA. Thus, the obese and stiffness of muscles were relatively contraindications for other surgical options. In the meantime, on account of a short incision, lacking field of vision and unclear anatomical landmarks, mini-invasive surgery may result in the inaccuracy of prosthesis placement. However, the SuperPATH technique was not a contraindication to obesity and muscularity, which further broadens the indications for resolution of intraoperative joint capsule exposures and anatomic landmarks [2]. Eskelinen A [27] suggested that we should pay more attention to the protection of tissue and placement of the prosthesis, but put the short incision (≤ 10 cm) into the secondary site simultaneously. Han SK et al [28] found that intraoperative protection of the external rotation muscles can reduce the postoperative dislocation rate from 1.8–6.2%.

In this study, 6 papers documented operation time. The results of this issue showed that there was no difference in operating time between the two groups, which may be closely related to the learning curve of the new SuperPATH technology. Rasuli KJ et al [6] reported 50 cases and 49 cases of SuperPATH and PATH minimally invasive approach for total hip arthroplasty respectively. They found that the operation time of the 50th case in the SuperPATH group was still in the process of decreasing, indicating that the learning curve can certainly prolong the operation time. Besides, the step of suturing the incision was often performed by junior physicians at the end of the surgical, and may to some extent affected the overall operation time.

Blood loss and transfusion rates in prosthetic hip operation were closely associated with the bleeding in the process of the osteotomy, intramedullary reaming of medullary cavity and cutting muscles. For the SuperPATH approach, smaller soft tissue dissection should be related to less bleeding as well as fewer transfusions rates. In this research, 6 studies mentioned intraoperative blood loss and blood transfusion rates were mentioned in 4 studies. There was no significant difference in intraoperative blood loss, but blood transfusion rates were significantly lower in the SuperPATH technique. The author believed that SuperPATH technology protects the joint capsule and external rotation muscles, which led to the possibility of less trauma, so the overall transfusion rate was less than the conventional group. As a new technique, surgeons may prolong operation time and increase blood loss for unskilled operation. Gofton W et al [5] and Rasuli et al [6] who performed this surgery, found the transfusion rates of SuperPATH minimally invasive surgery were 3.3% and 4.0% respectively, which were lower than those in the conventional approaches.

3 studies related to hospitalization time. The results showed that there was no significant difference between both. Cardenas-Nylander C et al [29] showed that the average length of stay undergoing SuperPATH technology was 1.4 days, less than that of the conventional THA. Gofton W et al [30] conducted a study of 30-day readmission rates for 479 patients who performed THA. The results showed that the 30-day readmission rate for the SuperPATH minimally invasive total hip arthroplasty fell from 4.3–2.3% compared with conventional procedures. Gofton W et al [5] analyzed 99 patients from April 2013 to January 2014. They found that even if the surgeons came into contact with SuperPATH, the overall costs of hospitalization were 28.4% lower than that of the conventional lateral approach. Thus, it significantly reduced postoperative costs. In this study, Meng et al [14] performed bilateral hip arthroplasty in succession and may reduce the whole length of stay to enhance recovery after surgery.

4 studies mentioned VAS and the subgroup analysis found that 1 week, 1 and 3 months after surgery in SuperPATH technology was significantly lower than in conventional surgery. However, results showed that during the 6 to 12 months follow-up of two groups, there had no difference in two groups. Based on the above discussion, SuperPATH technology improved patient satisfaction in the early postoperative period. Bodrogi AW et al [31] performed the SuperPATH technique in 17 patients with femoral neck fractures. By clinical follow-up, they found that postoperative analgesia dosage was reduced and the hospital stays were shortened. Jinquan L et al [32] measured the circumference of the thigh after SuperPATH surgery and found that the postoperative degree of edema was significantly lower than other small incision surgery, thus reducing the patient pain and other constrained symptoms.

The Harris hip score (HHS) was a widely used synthetical mark of evaluating the hip function and often used to assess the effect of hip replacement. In this meta-analysis, the HHS at week 1, month 1 and months 3 after the operation in the SuperPATH group was higher than those in the conventional replacement group, but there was no significant difference after the 6th month. Unfortunately, none of the included articles mentioned specific details of the HHS score. The author believed that HHS in the initial period was low in the SuperPATH replacement group, indicating a better early functional recovery. The difference in the middle period was not significant. But the overall follow-up was shorter, and the long-term efficacy needed observation. Through the collection of postoperative imaging measurements in 66 patients, Della Torre PK et al [2] found the early results in the SuperPATH group were superior to the conventional access group, but the long-term results needed further investigation.

Lewinnek GE et al [33] found that the dislocation rate for cup orientation with anteversion of 15 ± 10 degrees and lateral opening of 40 ± 10 degrees was 1.5 percent, with respect to minimizing the risk of dislocation in the postoperative period. Through the analysis of 2 studies, we found no difference in acetabular abduction angles comparing the SuperPATH group with the conventional group, but simultaneously showed a significant difference in acetabular anteversion angles. Archbold HA et al [34] reported that the transverse acetabular ligament was used to determine the position of the acetabular locator. This method is suitable for both conventional and minimally invasive procedures. Therefore, reaming and placement of the acetabular component referring to the transverse acetabular ligament can certainly improve the accuracy of the prosthesis position. Through the analysis of 50 cases for SuperPATH surgery, Rasuli KJ et al [6] also found that reference to acetabular transverse ligament during operation can increase the accuracy of the prosthesis and reduce the rate of dislocation. For this study, only two studies and 50 patients have enrolled which to some extent restrained the accuracy of our judgment.

This article also had some limitations: (1) Follow-up of each study and some of the evaluation indicators were inconsistent; (2) Lack of detailed score data and incidence of complications were not assessed; (3) We only identified the published papers, so unpublished articles may influence the ultimate result; (4) As the SuperPATH technology was first reported in 2011, the long-term efficacy and complications still need multi-centers, larger samples for follow-up observation.

The results of this meta-analysis showed that the short and medium-term postoperative hip-related scores of the SuperPATH approach were not significantly different from those of the conventional approach. However, the SuperPATH approach on account of shorter incision length, less postoperative transfusion rate, preferable early postoperative VAS and HHS showed that it was superior to the conventional approach. In the meantime, it had the potential advantages of low tissue damage and rapid postoperative recovery which can certainly improve patients' quality of life and satisfaction.

Conclusion

This suggested that SuperPATH was an advantageous approach and inaugurates an era of minimally invasive surgery for hip replacement. But for the limited number of studies and insufficient sample sizes, the conclusion should be treated cautiously. Consequently, larger sample sizes with well-designed RCTs were required to confirm the conclusion.

Abbreviations

SuperPATH: supercapsular percutaneously assisted total hip; WMD: Weighted Mean Difference; OR: odd ratio; CI: confidence interval; VAS: visual analogue scale; HHS: Harris hip score; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCTs: Randomized controlled trials; CCT: Clinical control trial; NOS: Newcastle-Ottawa Scale; THA: Total hip arthroplasty

Declarations

Availability of data and materials

All data are fully available without restriction.

Ethics approval and consent to participate

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

Consent for publication

Not applicable.

Competing interests

The authors Yanzhi Ge, Li Zhou, Zuxiang Chen, Ting Li, Peijian Tong and Letian Shan declare that they have no conflicts of interest.

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Authors' contributions

The following authors designed the study (YZG, PJT), collected the data (YZG, LZ), analysed the data (ZXC, TL), wrote the initial drafts (YZG), and ensured the accuracy of the data and analysis (PJT, LTS). All authors read and approved the manuscript.

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Figures

#1 “clinical trial”[PT] OR “follow up study”[PT] OR “randomized controlled trial”[PT] OR “cohort study”[PT]
#2 (((cohort[TIAB]) OR randomized[TIAB]) OR randomly[TIAB]) OR trial*[TIAB]) OR placebo[TIAB]
#3 #1 OR #2
#4 gonarthrosis[TIAB]
#5 “Osteoarthritis, Hip”[Mesh]
#6 “Femoral Neck Fractures”[Mesh]
#7 “Femur Head Necrosis”[Mesh]
#8 #4 OR #5 OR #6 OR #7
#9 approach*[TIAB]
#10 SuperPATH[TIAB]
#11 supercapsular percutaneously assisted total hip[TIAB]
#12 #9 OR #10 OR #11
#13 “Arthroplasty, Replacement, Hip”[Mesh]
#14 #3 AND #8 AND #12 AND #13

Figure 1

Pubmed search strategies

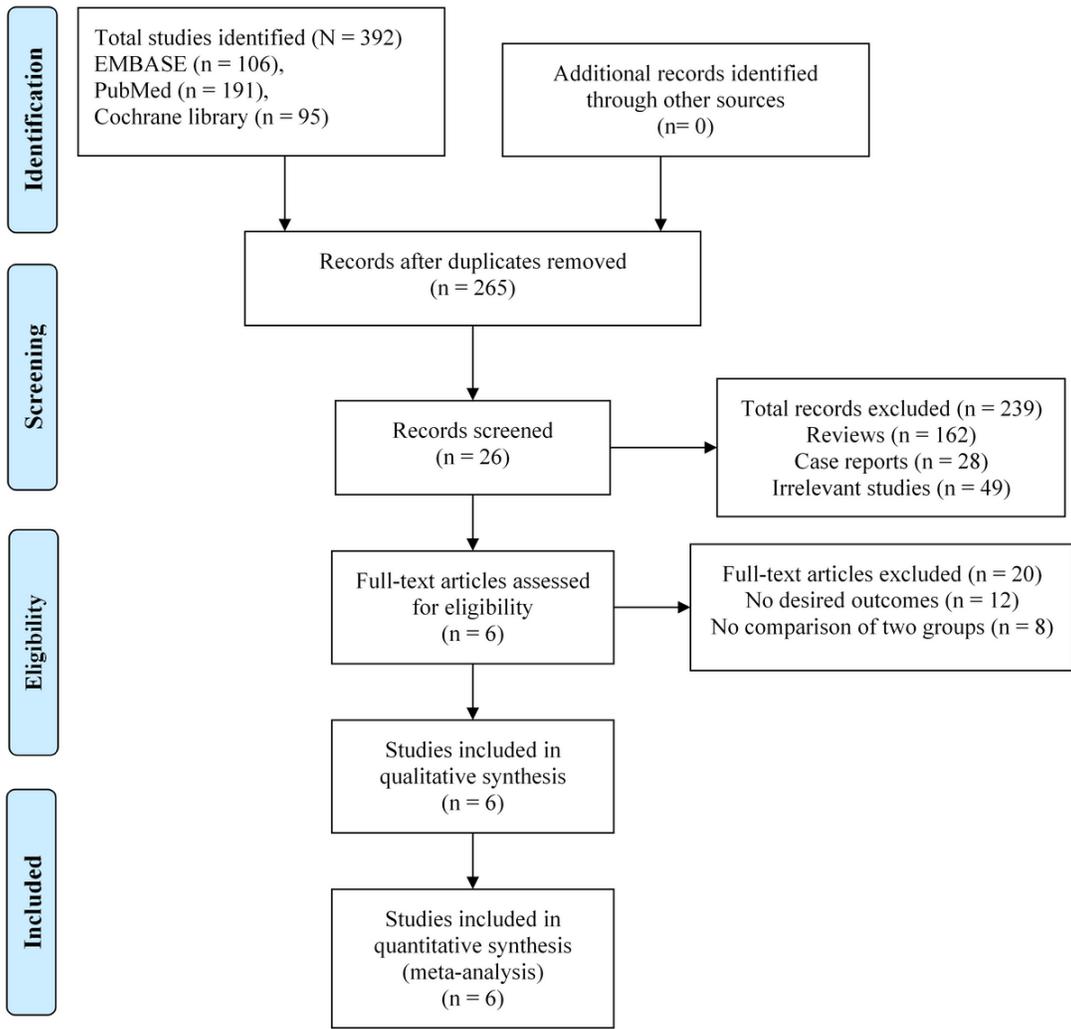


Figure 2

PRISMA study flow diagram

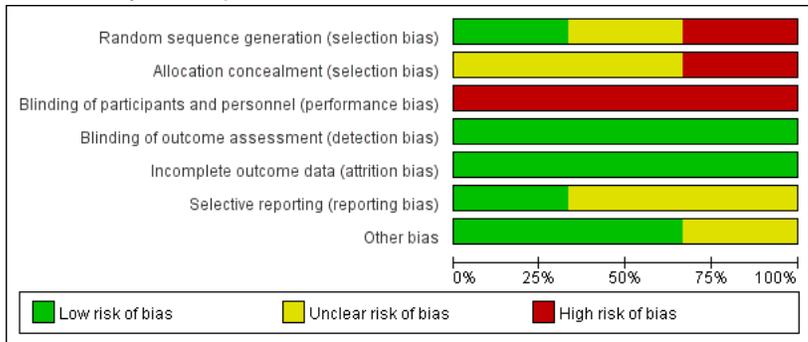


Figure 3

Risk of bias graph

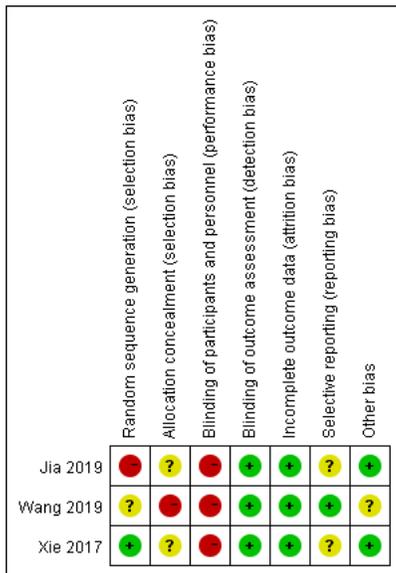


Figure 4

Risk of bias summary

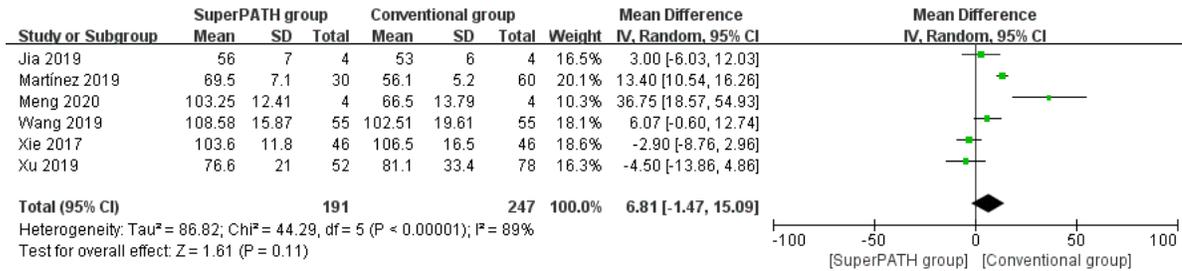


Figure 5

Operation time forest plot analysis comparing the SuperPATH group vs conventional group

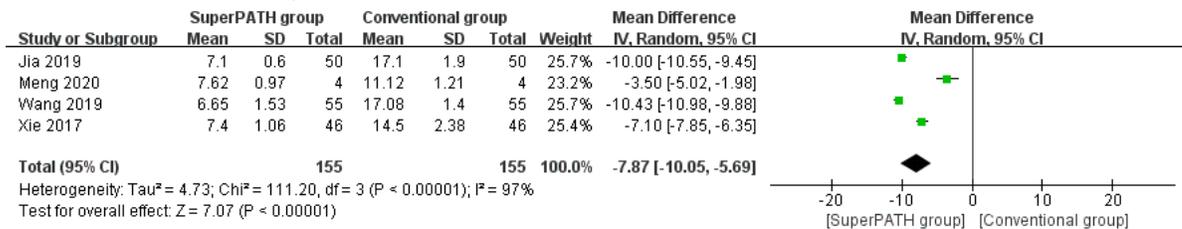


Figure 6

Incision length forest plot analysis comparing the SuperPATH group vs conventional group

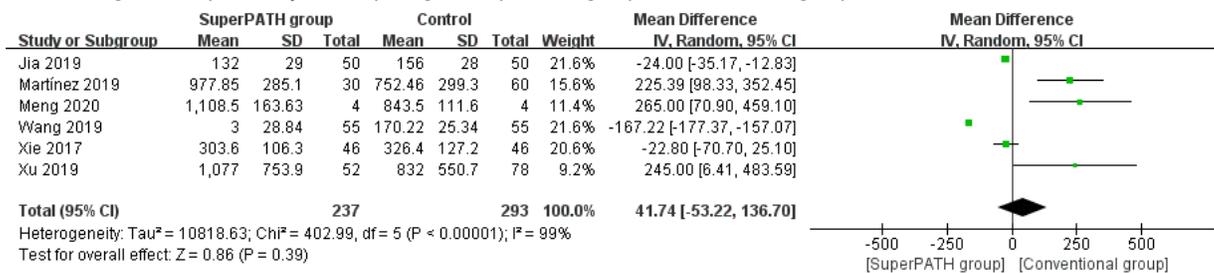


Figure 7

Blood loss forest plot analysis comparing the SuperPATH group vs conventional group

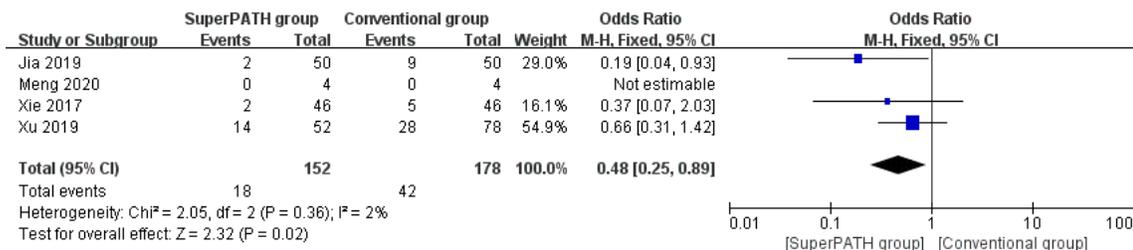


Figure 8

Transfusion rate forest plot analysis comparing the SuperPATH group vs conventional group

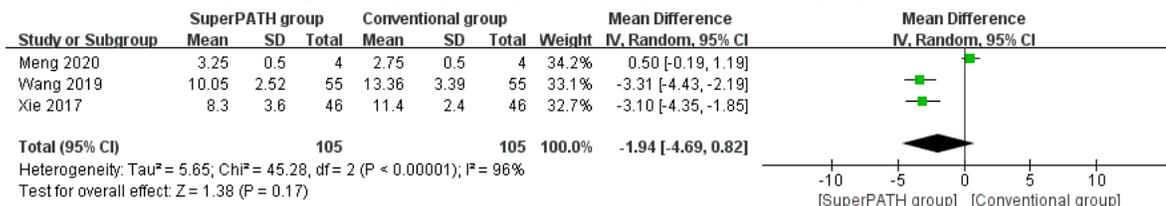


Figure 9

Length of stay forest plot analysis comparing the SuperPATH group vs conventional group

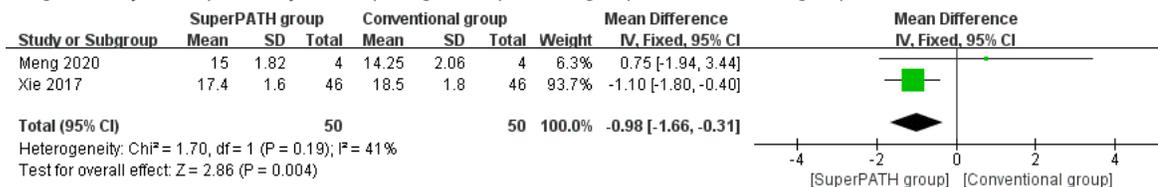


Figure 10

Anteversion angle forest plot analysis comparing the SuperPATH group vs conventional group

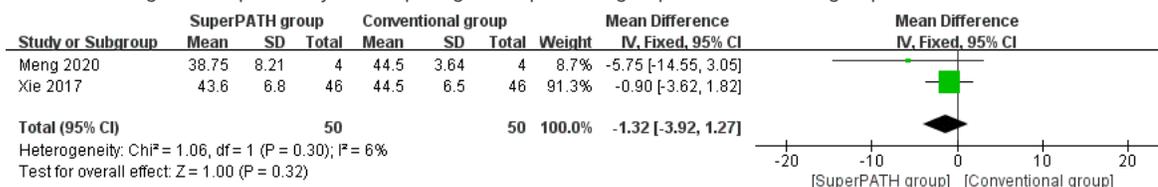


Figure 11

Abduction angle forest plot analysis comparing the SuperPATH group vs conventional group

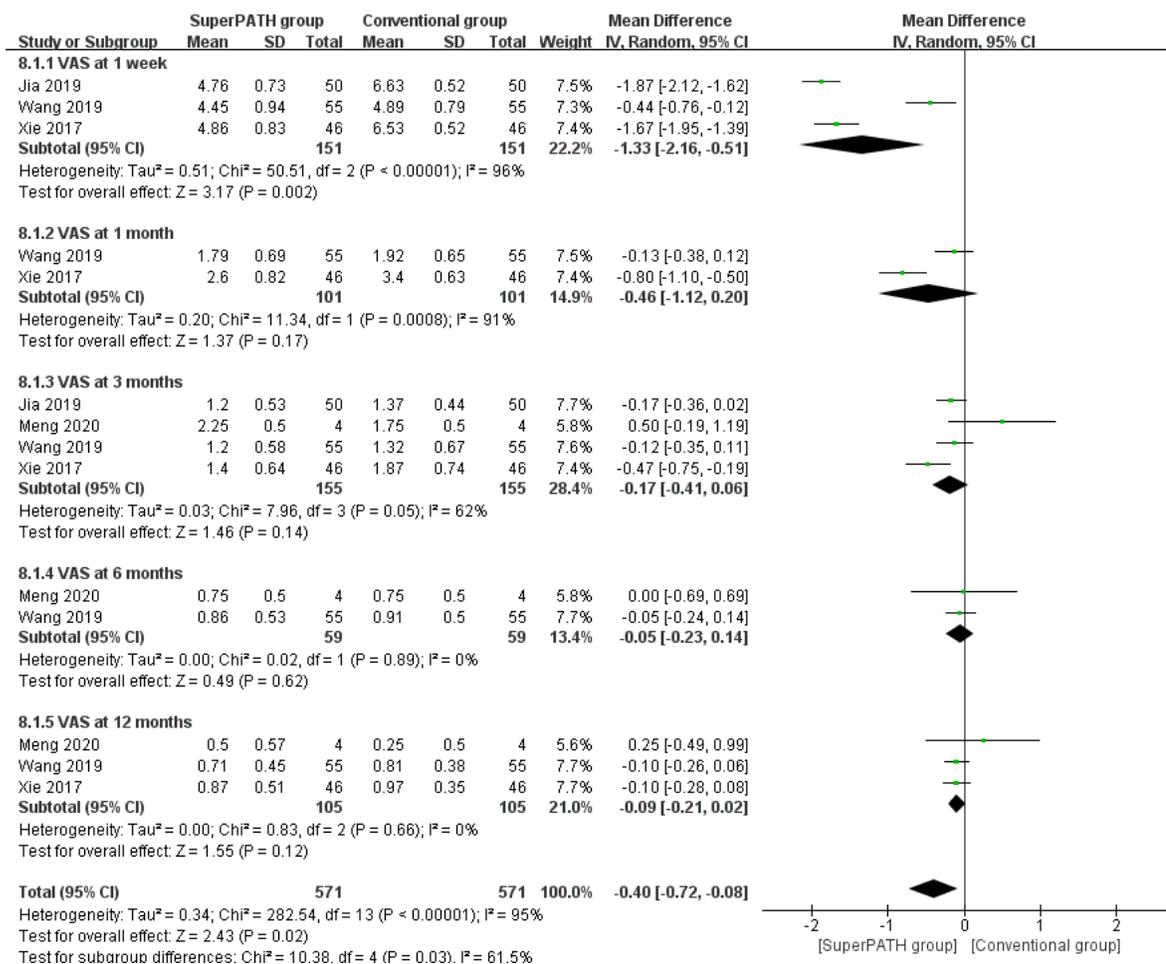


Figure 12

VAS forest plot analysis comparing the SuperPATH group vs conventional group

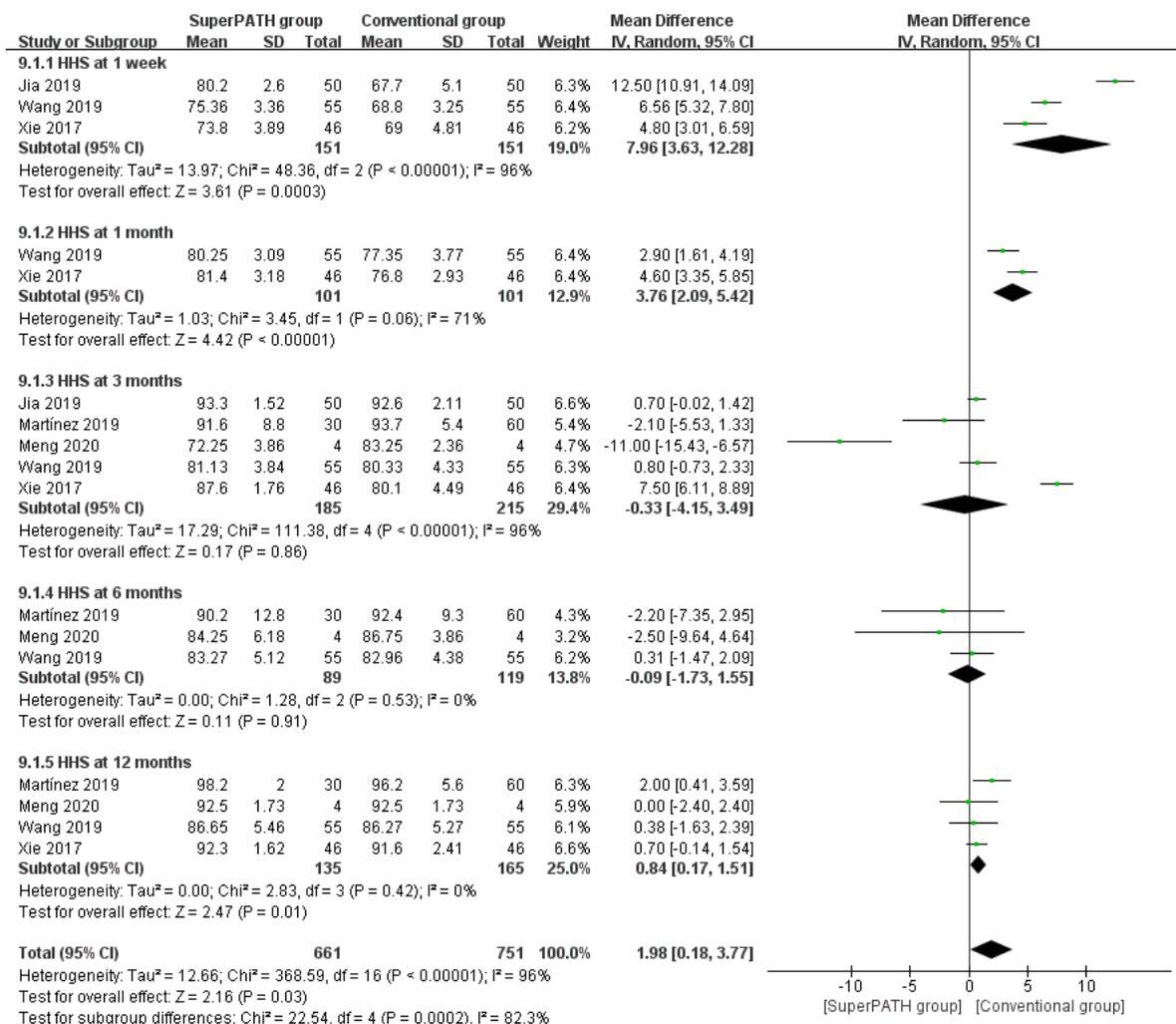


Figure 13

HHS forest plot analysis comparing the SuperPATH group vs conventional group