Systematic Review and Meta-Analysis

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Staged vs simultaneous bilateral unicompartmental knee arthroplasty for clinical outcomes

A protocol of systematic review and meta-analysis

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Abstract

Background: Bilateral unicompartmental knee arthroplasty (UKA) can be divided into one or two stages clinically. Compared with staged bilateral UKA, whether simultaneous bilateral UKA has better clinical efficacy remains to be verified.

Methods: PubMed, EBSCO, and Web of Science were searched by us for meta-analysis. Studies were considered eligible for inclusion if they included simultaneous and staged UKA. We excluded studies unrelated to the research question, studies in non-selected languages, and studies where the full-text was not available. The data were extracted by two independent investigators, and disagreements were resolved through discussions with a third party. If important data or information about the content of the paper were not available, authors were contacted. Publication bias in studies has been assessed. Meta-analysis was done using Review Manager 5.3.

Results: The systematic review and meta-analysis identified 3370 trials, of which 8 studies (963 patients) compared simultaneous with staged bilateral UKA. The meta-analysis showed that the clinical outcomes of simultaneous bilateral UKA goes down in operating time (weighted mean difference [WMD] = −19.34, 95% confidence interval [CI] −22.44 to −16.25, $P < .00001$), postoperative hemoglobin (Std. mean difference [SMD] = −0.46, 95% CI −0.71 to −0.20, P = .0004), length of stay (LOS) (WMD = −4.73, 95% CI −6.39 to −3.06, $P < .00001$), hospital cost (SMD = −5.42, 95% CI −6.54 to −4.30, $P < .00001$). There were no significant difference in blood transfusion, venous thrombosis, infection, cardiac complications, pulmonary complications, Oxford Knee Score (OKS) between simultaneous and staged bilateral UKA.

Conclusion: Simultaneous bilateral UKA can effectively reduce the operating time, LOS, and hospital cost without increasing postoperative complications compared to stage bilateral UKA.

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Abbreviations: LOS = length of stay, OKS = Oxford Knee Score, UKA = unicompartmental knee arthroplasty.

Keywords: simultaneous, staged, unicompartmental knee arthroplasty

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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1. Introduction

Patients with bilateral knee osteoarthritis (OA) that require surgery can opt for a staged bilateral operation, a period of time between operations. Alternatively, a simultaneous bilateral operation may be performed, which is a one-time bilateral knee arthroplasty. Studies have shown that at least 20% of patients who undergo primary total knee arthroplasty (TKA) were affected by bilateral OA and require surgery on the contralateral knee within a few years of the initial surgery.[1,2]

There have been many reports on simultaneous TKA, but few reports on simultaneous and staged unicompartmental knee arthroplasty (UKA) of bilateral knee joint unicompartmental OA.[3,4] Some reports have suggested that UKA has faster functional recovery, and fewer long-term follow-up failures than TKA.[5,6] With smaller incisions and less blood loss, UKA is considered a minimally invasive and safer surgery.[5] In addition, UKA has a shorter duration of anesthesia and hospital stay.[6–8] UKA is a valuable surgical method for the treatment of bilateral knee joint unicompartmental OA. Studies have proved that the 10-year survival rate of UKA is between 85% and 95%,[9,10] and the 20-year survival rate is about 85%.[11,12] One-third of

patients with knee OA occur primarily in one chamber.[13] Compared with TKA, UKA reduces pain and improves clinical outcomes,[14] improves patients' quality of life, and allows excellent recovery of physical activity, which is especially important for younger patients.[15] Some scholars believed that simultaneous bilateral UKA surgery, instead of two-stage surgery, can reduce the management cost, hospital stay and recovery time of patients,[3,16,17] while others believed that it increases bleeding, operation time, perioperative complications, revision rate, mortality rate, and blood transfusion rate.[4,18] In a retrospective study that showed a significantly higher incidence of major complications in the concurrent group, the authors suggested that surgeons should use a staged approach.[4] With the increasing use of UKA by surgeons, it is particularly important to study the functional outcomes and perioperative risks of staging or synchronous bilateral surgery.

Several high-quality literatures have been published without conclusive results. The clinical outcome and perioperative risk of simultaneous and staged bilateral UKA remain unclear. In this study, the efficacy and safety of simultaneous versus staged bilateral UKA were evaluated by meta-analysis to guide the selection of clinical surgery.

2. Methods

2.1. Study registry

The protocol was registered on the PROSPERO (International prospective register of systematic reviews) (CRD42020160056). All literatures were based on published studies and the meta-analysis did not require ethical approval or patient consent. Systematic review and meta-analysis accord with PRISMA[19] guidelines (the preferred reporting item for systematic review and meta-analysis), and AMSTAR guidelines (assessing the methodological quality of systematic review).

2.2. Search methodology

Two professionally trained researchers independently searched PubMed, Cochrane library and Web of Science without restrictions on publication date. We tried to identify all the published trials that might be relevant. We use a hierarchical approach based on title, summary, and full text to assess relevance. Search terms also included their synonyms: "one staged (All Fields)" OR "simultaneous bilateral (All Fields)" AND "two staged (All Fields)" OR "staged bilateral (All Fields)" AND "unicompartmental knee arthroplasty (All Fields)" OR "unicompartmental knee replacement (All Fields)" OR "UKA (All Fields)." The researchers used the Boolean operator "and" or "or" to combine search terms. To ensure the comprehensiveness of the study, we also manually searched the reference list of relevant articles to identify other trials.

2.3. Selection criteria

2.3.1. Inclusion criteria.

1. Participants: patients who underwent primary bilateral UKA;
2. Interventions: the intervention group received simultaneous bilateral UKA;
3. Comparisons: the control group received staged bilateral UKA;
4. Outcomes: The literature contains data for at least one of the following results: operating time, postoperative hemoglobin, blood transfusion, venous thrombosis, infection, cardiac complications, pulmonary complications, OKS, LOS, hospital cost.
5. Study design: comparative studies were regarded as eligible for systematic review and meta-analysis.

2.3.2. Exclusion criteria.

1. Studies that merely reported simultaneous or staged bilateral UKA without comparison.
2. The design of the experiment is not reasonable.
3. Repeated reports, systematic review and meta-analysis.
4. Animal experiments.

2.4. Study selection

All possible relevant studies searched in the database were imported into the software Endnote X9 and duplicated literatures were excluded through the functional options of the software. Then, the two researchers who had previously searched the database read the title and summary to initially rule out the study that did not meet the requirements. Finally, the two researchers further excluded those that did not meet the selection criteria by reading the full text of the remaining studies, and resolved differences by discussing them with a third researcher.

2.5. Data extraction

First author's name, publication year, mean age, sample size, BMI, country and outcomes, these data were extracted separately by the same two researchers from the studies that were eventually included. Operating time, postoperative hemoglobin, blood transfusion, venous thrombosis, infection, cardiac complications, pulmonary complications, OKS, LOS, hospital cost were also incorporated into main outcomes. Blood transfusion rate can reflect blood loss and safety, postoperative complications can indicate perioperative risk and surgical safety, and other secondary results include hospital costs.

2.6. Assessment of study quality

Two researchers independently assessed the quality of included studies. Eight studies were classified as cohort studies and the literatures quality of cohort studies were assessed using the Newcastle-Ottawa scale (NOS), with a full score of 9, >7 is classified as higher quality, 5 to 7 as medium quality, and a score ≤ 5 is a low quality.

2.7. Statistical analysis

Studies were analyzed using forest plots generated with Review Manager 5.3. Dichotomous data were reflected by proportions, such as rates of transfusions and various complications. The Intervention effect were reflected by odds ratio (OR). Continuous data, such as OKS, LOS, and hospital costs, were analyzed in terms of the weighted mean difference (WMD) and associated 95% confidence interval (95% CI).'Continuous data used by different ways in different studies were analyzed by standardized mean difference (SMD).

Fixed effect model was used to no statistical heterogeneity ($I^2 < 50\%$), and random effect model was adopted to significant heterogeneity ($I^2 \geq 50\%$). Funnel plot was used to check whether the included literature has deviation. Medians and ranges in studies were transformed into means and standard deviations (SD) using Hozo formula.[20]

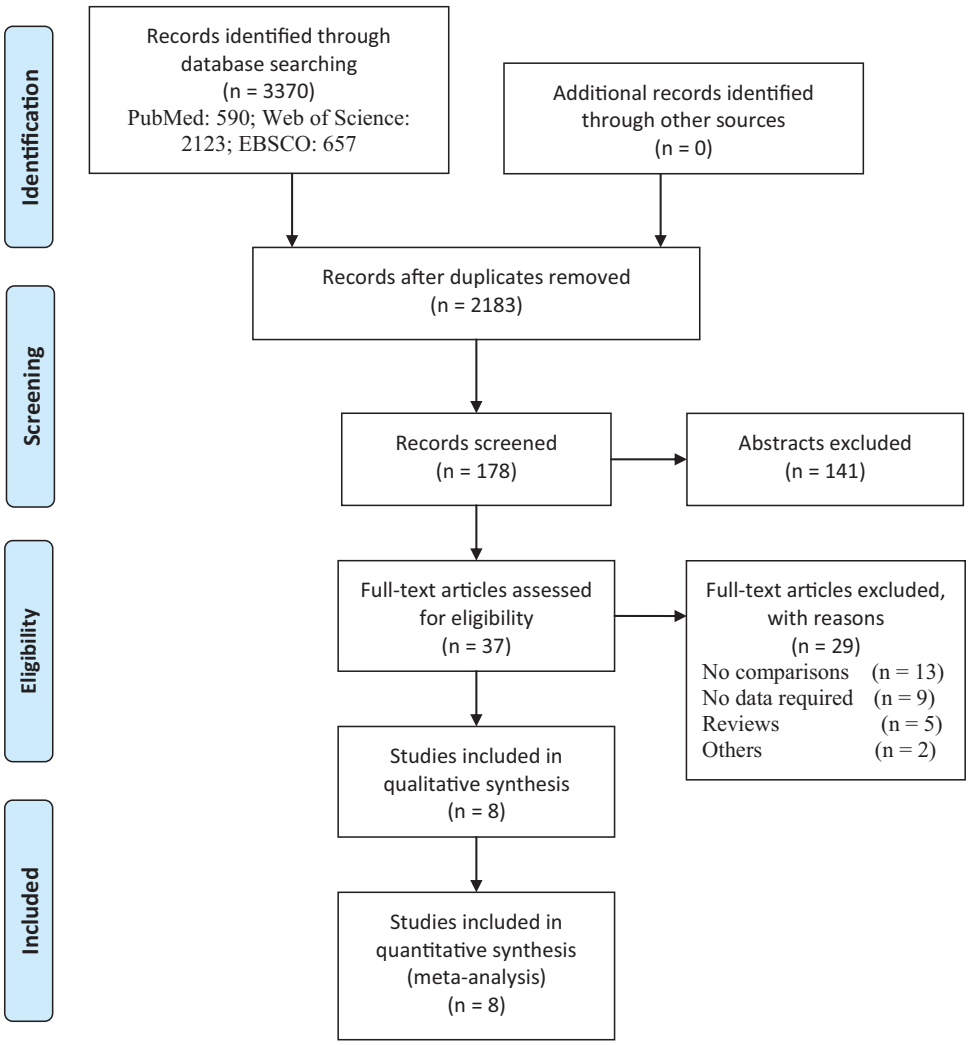

Figure 1. The flow diagram of study selection.

3. Results

3.1. Study characteristics and quality evaluation

3370 literatures were identified according to the search term, after duplicates removed using software Endnote X9, 2,183 remained. According to the inclusion and exclusion criteria, 29 literatures were excluded. In the end, 8 cohort studies were included in this meta-analysis. The process of study selection shown in Figure 1.

Table 1 displays general characteristics of the included studies. Eight cohort studies totaling 963 patients were included, in which 505 patients were selected for simultaneous bilateral

Table 1

General characteristic of the included studies.

		Simultaneous/staged bilateral UKA				
Author	**Mean age (years)**	**No. of patients (n)**	**Female**	**BMI**	**Country**	**Outcomes**
Berend[3] 2011	58.2/62.7	35/141	NC	30.9/33.3	USA	6.7
Biazzo[21] 2019	70.4/68.5	51/51	38/32	29.47/28.97	Italy	3
Chan[4] 2009	66.0/66.4	159/80	67/45	NC	UK	1.4.5.6.7
Chen[16] 2013	62.9/61.6	124/47	91/36	27.3/26.8	Singapore	1.2.3.4.5.6.7.8.9.10
Feng[22] 2019	64.9/64.2	39/54	33/49	23.9/23.5	China	2.3.5.7.9.10
Ma[23] 2015	65.6/65.3	36/45	21/27	25.0/25.5	China	1.2.4.5.8
Siedlecki[24] 2018	69.2/70.0	44/26	24/19	26.8/26.3	France	1.2.3.9.10
Su[25] 2019	67.7/71.2	17/14	10/8	25.84/25.26	China	1.2.9.10

1. Operating time, 2. postoperative hemoglobin, 3. blood transfusion, 4. venous thrombosis, infection, 6. cardiac complications, 7. pulmonary complications, 8. Oxford Knee Score, 9. length of stay, and 10. hospital cost.

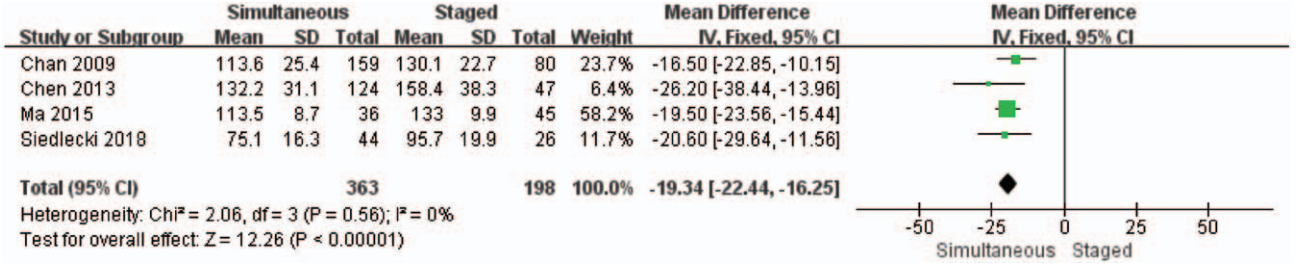

Figure 2. Forest plot comparing the two surgical options in operating time.

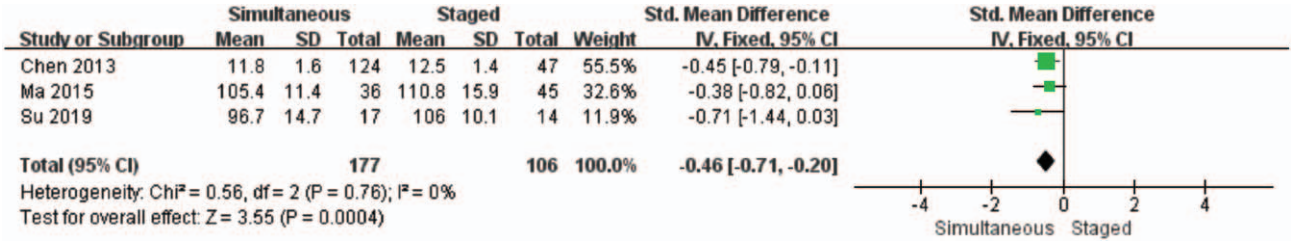

Figure 3. Forest plot comparing the two surgical options in postoperative hemoglobin.

UKA, and 458 patients for staged bilateral UKA. Eight cohort studies were evaluated by the Newcastle-Ottawa scale risk of bias assessment tool. All studies were recent trials published from 2001 to 2020. The follow-up has long time ranged from 1 to 50 months.

3.2. Risk of bias

We adopted Newcastle–Ottawa quality scale (NOS) and made strict evaluation on the quality of the included Cohort studies from the aspects of Selection, Comparability, and Outcome. With a full score of 9, ≥7 for high quality literature, 5 to 7 for medium quality literature, and <5 for low quality literature. The NOS scores for Cohort studies ranged from 5 to 7, which indicated that the included literatures had medium qualities.

3.3. Outcomes

3.3.1. Operating time. The results of 4 studies (561 participants) indicated that simultaneous bilateral UKA has a lower operating time than staged bilateral UKA, with a statistically significant difference (WMD = −19.34, 95% confidence interval (CI) −22.44 to −16.25, $P < .00001$, Fig. 2).

3.3.2. Postoperative hemoglobin. Three studies (283 participants) reported a comparison of the postoperative hemoglobin after UKA, and results showed that simultaneous bilateral UKA had a lower postoperative hemoglobin (SMD = −0.46, 95% CI −0.71 to −0.20, $P = .0004$, Fig. 3).

3.3.3. Blood transfusion. Four studies (436 participants in total) recorded blood transfusion rate for both surgical approaches, and the results obtained can prove that there was no statistically significant difference in blood transfusion between the two surgeries (Fig. 4).

3.3.4. Venous thrombosis. Three studies (491 participants) recorded a comparison of venous thrombosis after two types of surgery, showing that simultaneous bilateral UKA was less likely to staged bilateral UKA (Fig. 5).

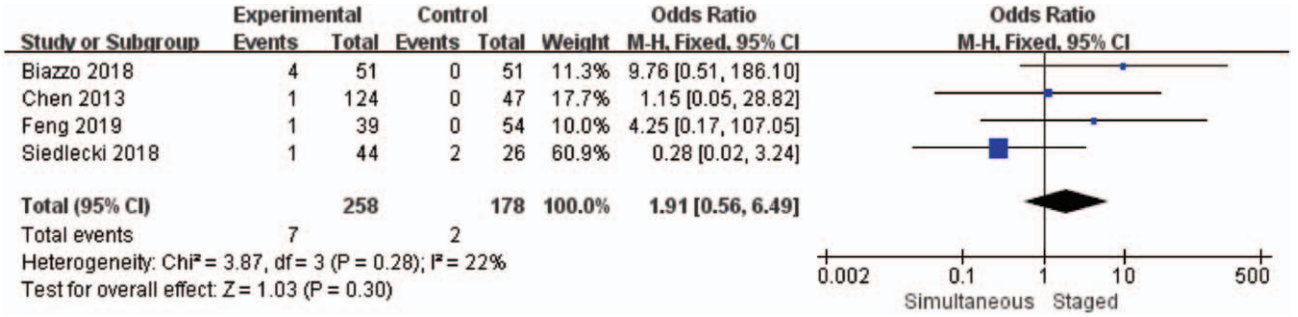

Figure 4. Forest plot comparing the two surgical options in blood transfusion.

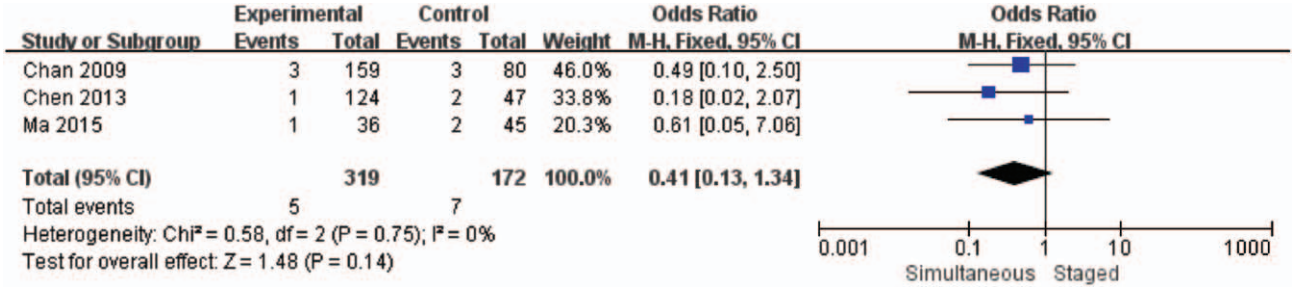

Figure 5. Forest plot comparing the two surgical options in venous thrombosis.

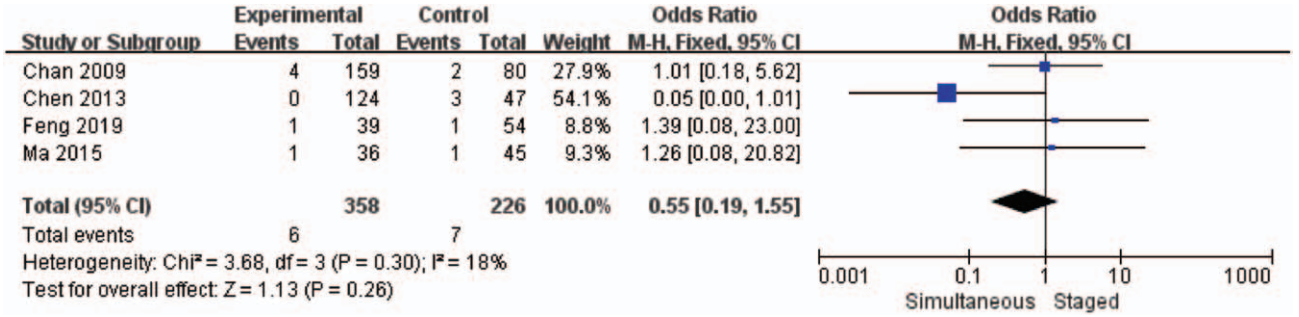

Figure 6. Forest plot comparing the two surgical options in infection.

3.3.5. Infection. Four studies (584 participants) reported a comparison of infection rates after the two surgeries, and the results obtained can prove that there was no statistically significant difference (Fig. 6).

3.3.6. Cardiac complications. Three studies (586 participants) reported a comparison of the incidence of cardiac complications after the two surgeries, and the results obtained can prove that there was no statistically significant difference in cardiac complications between the two surgeries (Fig. 7).

3.3.7. Pulmonary complications. Four studies (679 participants) reported a comparison of pulmonary complications after two types of surgery. The results obtained can prove that there was no significant difference in pulmonary complications (Fig. 8).

3.3.8. OKS. Two studies (252 participants) reported a comparison of the OKS after the two surgeries, and the results showed that the difference was no statistically significant (Fig. 9).

3.3.9. LOS. Four studies involving 365 participants reported a comparison of the LOS after the two surgeries. The results showed that simultaneous bilateral UKA has a lower LOS (WMD = −4.73, 95% CI −6.39 to −3.06, $P < .00001$, Fig. 10).

3.3.10. Hospital cost. Four trials totaling 365 patients provided data on hospital cost. Compared with staged bilateral UKA, simultaneous bilateral UKA was associated with a reduction in the hospital cost (SMD = −5.42, 95% CI −6.54 to −4.30, $P < .00001$, Fig. 11). The funnel plot of hospital cost contains many literatures, which show the basic symmetry of literatures, indicating that the possibility of deviation is very small (Fig. 12).

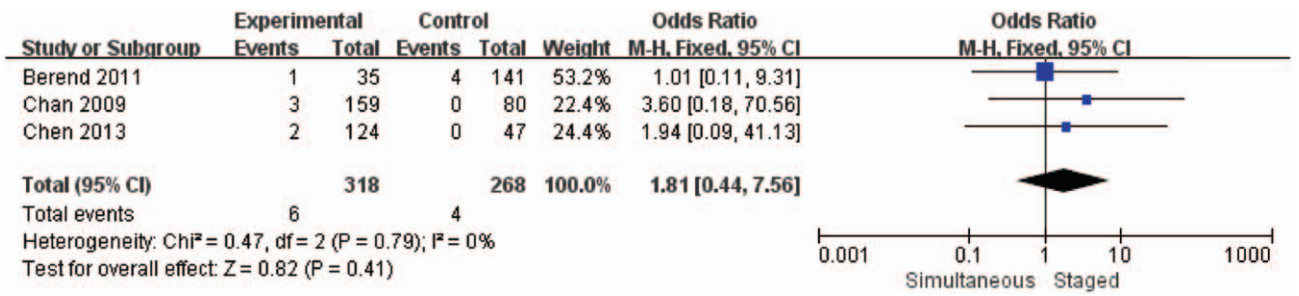

Figure 7. Forest plot comparing the two surgical options in cardiac complications.

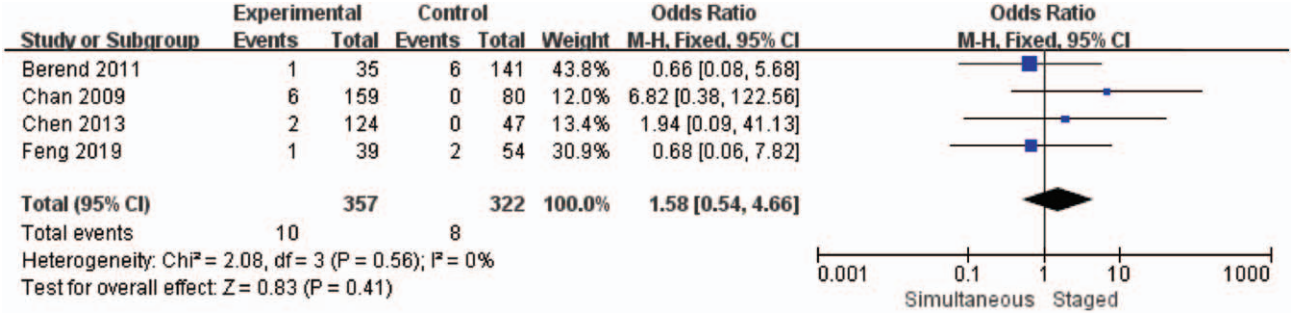

Figure 8. Forest plot comparing the two surgical options in pulmonary complications.

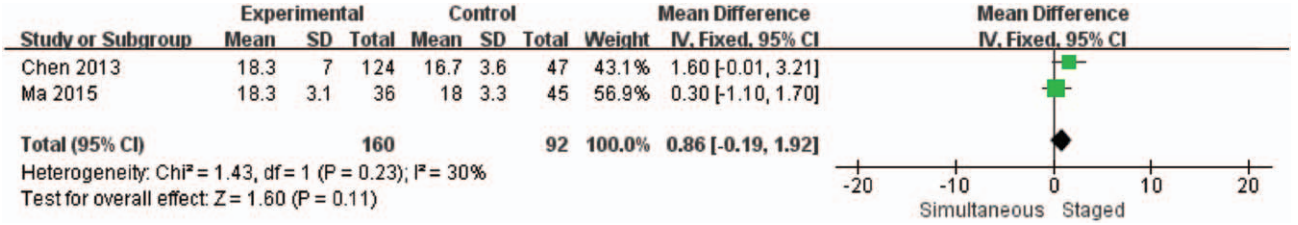

Figure 9. Forest plot comparing the two surgical options in Oxford Knee Score.

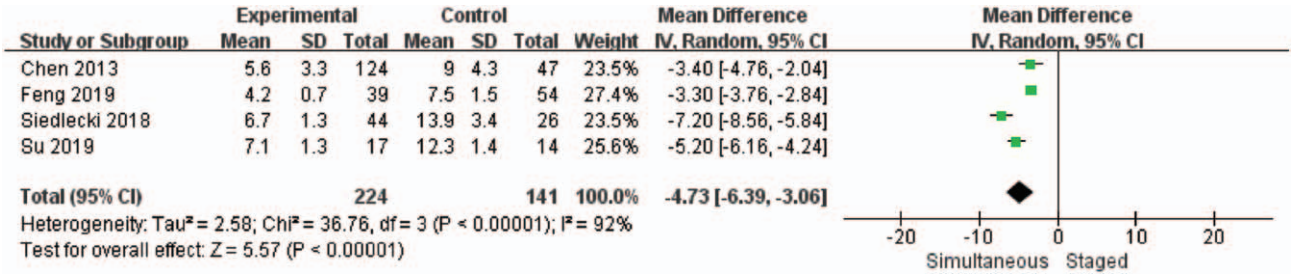

Figure 10. Forest plot comparing the two surgical options in length of stay.

4. Discussion

4.1. Main findings

The meta-analysis showed that simultaneous bilateral UKA has significant difference in terms of operating time, postoperative hemoglobin, LOS, as well as hospital cost compared with staged bilateral UKA. The meta-analysis found no statistically significant difference in risk for blood transfusion, venous thrombosis, infection, cardiac complications, pulmonary complications, OKS.

4.2. Implications for clinical practice

The main research aspect of this paper was to compare the perioperative risk and clinical outcomes of the two surgical methods. Although the surgical approach of simultaneous

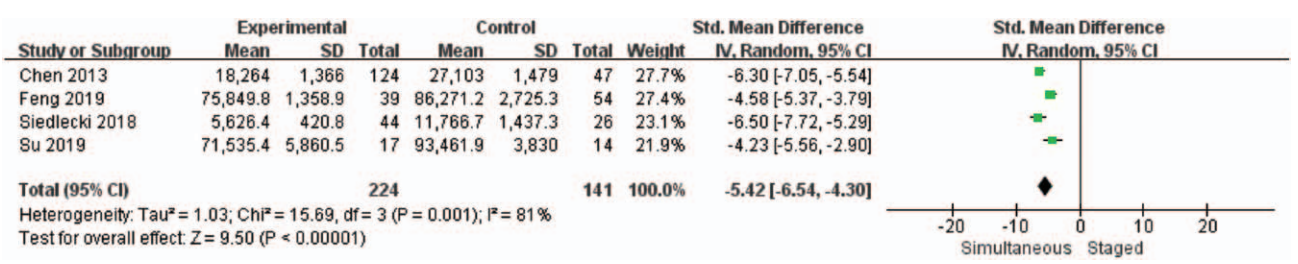

Figure 11. Forest plot comparing the two surgical options in hospital cost.

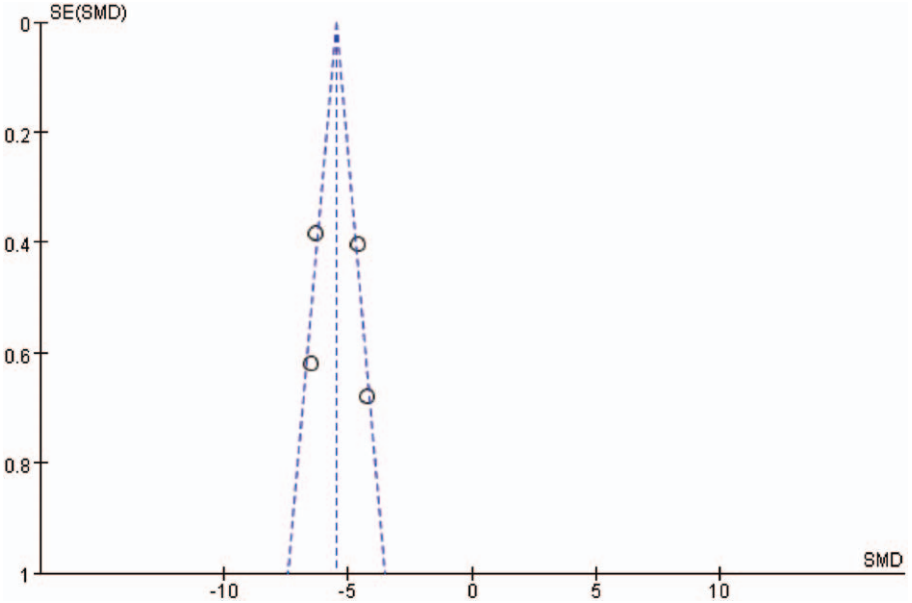

Figure 12. Funnel plot for comparing two groups in terms of hospital cost.

bilateral UKA was more effective in reducing operating time, LOS, and hospital cost, postoperative hemoglobin was significantly reduced after simultaneous bilateral UKA.

Our research shows that simultaneous bilateral UKA is superior to staged bilateral UKA in terms of operating time, LOS, and hospital cost. Taking into account the number of single anesthesia and hospitalizations of simultaneous bilateral UKA, it is expected that the total time of surgery and hospitalization will be shorter. The reason for the lower cost of simultaneous bilateral UKA may be due to the lower cost of a single operating room and personnel.

Studies have shown that the postoperative hemoglobin level of simultaneous bilateral UKA is low. Most studies measure postoperative hemoglobin levels, but this may not reflect the amount of bleeding. Although some people think that simultaneous bilateral UKA loses more blood, research shows that it does not lead to an increase in the need for blood transfusion.

Although there are concerns that simultaneous bilateral UKA may cause a higher complication rate, our meta-analysis found that compared with staged bilateral UKA, simultaneous bilateral UKA does not have a higher all-cause complication rate.

4.3. Innovation and uniqueness

This meta-analysis established clear criteria for inclusion and exclusion of literatures, and carried out a strict evaluation on inclusion literatures. The benefits of this meta-analysis include the inclusion of the latest articles and the exclusion of the more heterogeneous ones. Prospective and retrospective cohort studies classified as cohort studies were included in the meta-analysis, which has a relatively high level of quality. As can be seen from the tree diagram, the heterogeneity among the literatures were very small, all *I*-square (I^2) close to 0, so the results obtained in this study were accurate.

4.4. Limitations

There is a lack of research on randomized controlled trial (RCT) in clinical trials, the lack of high-quality RCT literatures may reduce the reliability of the results. Publication bias existed in this paper, however, the result of bias is small and within the acceptable range according to the funnel plot. In some literatures, there were differences in age, BMI, preoperative ASA class, etc. The follow-up time and functional evaluation indexes of each study were inconsistent, and most of them could only be used for descriptive analysis.

5. Conclusion

In conclusion, Simultaneous bilateral UKA is generally appropriate as a surgical method, which can effectively reduce operating time, LOS, and hospital cost. Simultaneous bilateral UKA does not increase postoperative complications, although it reduces postoperative hemoglobin compared with staged bilateral UKA.

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Author contributions

WC, SF, and XYC designed the study, analyzed the data, and wrote the manuscript. JNS, ZHH, and YZ were also involved in study design.

Conceptualization: Wang Chen, Jian-Ning Sun, Ye Zhang, Xiang-Yang Chen, Shuo Feng.
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Validation: Wang Chen, Xiang-Yang Chen.
Visualization: Wang Chen, Jian-Ning Sun, Xiang-Yang Chen.
Writing – original draft: Wang Chen.
Writing – review & editing: Xiang-Yang Chen, Shuo Feng.

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