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Comparison of the clinical outcomes of revision of failed UKAs to TKAs with primary TKAs

A systematic review and meta-analysis

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Abstract

Unicompartmental knee arthroplasty (UKA) is one of the effective surgical methods for the treatment of unicompartmental knee arthritis. When UKA fails, a revised surgery to total knee arthroplasty (TKA) is often necessary. The purpose of this study was to compare the clinical outcomes of revision of failed UKAs to TKAs with primary TKAs. The hypothesis was that the TKAs revised from UKAs had inferior clinical outcomes compared with primary TKAs.

This meta-analysis was conducted in accordance with the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines. Newcastle-Ottawa Scale (NOS) proposed by the Cochrane Collaboration was used for evaluating the methodological quality of the studies. PubMed, Medline, Embase, Web of Science, and the Cochrane Library were searched to identify studies that compared the revision of UKA to TKA with primary TKA. Primary outcomes included Range of motion (ROM); Knee society score (KSS); (re-)revision rate and complications. Secondary outcomes were blood loss and length of hospital stay.

A total of 8 eligible retrospective comparative studies were identified from a keyword search. Results revealed that the primary TKAs group has a better ROM (MD = −7.29, 95% CI:−14.03–0.56, $P < .05$), higher Knee Society Knee scores (MD = −0.54, 95% CI:−1.12–0.04, $P < .05$), higher Knee Society function score (MD = −0.65,95% CI:−1.25–0.06, $P < .05$), lower (re-)revision rate (MD = 4.15, 95% CI:2.37–7.25, $P < .05$) than rUKAs. There was no significant difference in postoperative complications, blood loss and length of stay between the 2 groups.

Our meta-analysis revealed that compared with primary TKAs, TKAs revised from UKAs had inferior clinical outcomes.

Abbreviations: CI = confidence intervals, KSS = knee society score, MD = mean difference, MOOSE = Meta-analysis Of Observational Studies in Epidemiology, NOS = Newcastle-Ottawa Scale, ROM = range of motion, TKA = total knee arthroplasty, UKA = unicompartmental knee arthroplasty.

Keywords: meta- analysis, total knee arthroplasty (TKA), unicompartmental knee arthroplasty (UKA)

1. Introduction

Unicompartmental knee arthroplasty (UKA) is an effective surgical method for the treatment of unicompartmental knee arthritis.[1–3] Compared with total knee arthroplasty (TKA), UKA is only used to perform osteotomy, replacement of the lesion compartment, and preserves the anterior cruciate ligament as well as its normal structure. Therefore, it is associated with smaller operative trauma, better postoperative joint function and higher patient satisfaction.[4–6] As the number of UKAs rises, revisions of UKAs are also increasing. When UKA fails, a revision procedure to TKA is often necessary. In recent years, there was an increasing number of studies on failed UKAs converted to TKAs. It is still a controversy whether revision of failed UKAs to TKAs can achieve comparable clinical outcomes with that of primary TKAs. Some studies have reported that the outcomes of revision of failed UKAs to TKAs were comparable with that of primary TKAs.[7–9] However, few reports have demonstrated contrast results.[10–12] Therefore, the purpose of this study was to compare the clinical outcome of revision of failed UKAs to TKAs with primary TKAs.

2. Materials and methods

2.1. Date sources and search strategy

This meta-analysis was conducted in accordance with the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Guidelines. Ethical approval was not required for this study as reviewing of existing literatures did not involve any individual patient data. PubMed, Medline, EmBase, Web of Science, and Cochrane library databases were searched till November 2017 for comparative studies involving clinical results of revision of UKA to TKA and primary TKA. Two authors (ZW and MJH) completed the article search with the help of the librarians. The search terms include: "revision of UKA" OR "revision of unicompartmental

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knee replacement" OR "revision of unicondylar knee arthroplasty" OR "revision of unicondylar knee replacement" AND "primary TKA" OR "primary total knee replacement". Then, the articles were searched by abstract and title. Publication language was limited to English. Reference lists of all eligible studies and relevant reviews were manually searched for any additional trials.

2.2. Inclusion and exclusion criteria

Selection criteria.

The criteria used by 2 authors to select studies for the current meta-analysis are listed as below.

The inclusion criteria were studies including:

1. Comparative study design
2. Comparison clinical outcomes between revision of UKA to TKA and primary TKA
3. At least 1 post-operative outcome of interest reported.

The exclusion criteria were those studies that were:

1. Case reports
2. Non-comparative studies or non-human studies
3. Lacking in scientific design

2.3. Study quality assessment

Newcastle-Ottawa scale (NOS)[13,14] proposed by the Cochrane Collaboration was used for evaluating the methodological quality of the studies by 2 authors (W.Z. and J.H.M.), and disagreement was resolved by discussion. Three domains were assessed, (selection, comparability, and outcome), with 4 categories in the selection domain, 1 category in the comparability domain, and 3 categories in the outcome domain. The total possible score was 9 points. Disagreements between the 2 authors were resolved by consensus (Table 2).

2.4. Data extraction

All potentially eligible studies identified by searches were independently reviewed by 2 authors (W.Z. and J.H.M.). The disagreement was resolved by discussion. Data from articles that met the inclusion were abstracted independently by 2 authors (W. Z. and J.H.M.), including patient characteristics (age, sex, and other baseline characteristics), trial design, total participants and allocation, trial outcomes (Table 1). Primary outcomes included ROM, KSS score, (re-)revision rate and complications. Secondary outcomes were loss of blood and length of hospital stay.

2.5. Statistical analysis and synthesis of results

Review Manager Software (Revman v5.3) was used to calculate experimental data from the included studies. Odds ratios with 95% confidence intervals (CI) and the mean difference (MD) with 95% CI were adopted for dichotomous and continuous outcomes respectively. Publication bias may exist due to the limited number of included studies. Thus, the random effect model was used for meta-analysis as it includes the heterogeneity of data, and can also provide a relatively conservative overall evaluation. In the Cochrane guide, the asymmetry expression of funnel plot suggests the existence of publication bias. However, due to the limited number of the included studies, it is impracticable to use the funnel plot in our study. In addition, owing to the insufficient number of extracted data, subgroup analysis cannot be implemented, either. Sensitivity analysis was carried out to explore the impact of an individual study by deleting 1 study each time.

2.6. Investigation of heterogeneity

Heterogeneity among the trials was estimated by Q statistics and I^2. The value of I^2 statistic represents that the extent of variation is due to heterogeneity instead of chance. If $I^2 > 50\%$, it means that substantial heterogeneity exists. Therefore, a random effect model was used to assess the outcome. If the substantial heterogeneity still exist, the subgroup analysis was used to interpret the potential source of heterogeneity. Considering the importance of inconsistency depends on several factors, therefore, interpreting the threshold of I^2 may be misleading. $I^2 < 50\%$ and P value $> .1$ represent that the heterogeneity may not be important and a fixed effect model was used to evaluate the outcome (Figs. 1–8).

2.7. Dealing with missing data

When the data of included studies were incomplete, we contacted the authors to acquire the integrated information. The extracted data were presented as the form of mean ± standard deviation (SD) in this meta-analysis. According to the Cochrane Handbook for Systematic Reviews, when the extracted data were presented as median and interquartile range (IQR), we assumed that the median was equivalent to the mean and that the width of the IQR was equivalent to 1.35 times the SD. If the data were presented in a figure, Get Data software was used to estimated means ± SD.

3. Results

1. Search results: The literature search identified 356 studies in total and 158 of them were excluded due to duplication. After reading the titles and abstracts, 15 studies were screened out. Having read the abstracts and full text articles, we further excluded 6 studies due to ineligibility and 1 study lacked the outcome measures of interest.[11,15–21] Finally, there were 8 eligible studies with a total of 731 patients from case control studies and 34,574 patients from the New Zealand Joint Registry for data extraction and meta-analysis.
2. Range of motion (ROM): Four studies (N = 342) provided the postoperative ROM data. Results revealed that pTKA group had a better ROM than rUKA to TKA group (MD = −7.29, 95% CI:−14.03–0.56, $P < .05$).
3. (Re-)Revision rate: Five studies (N = 34,930) provided the (re-) revision rate data. Meta-analysis results revealed that rUKA group had a higher (re-)revision rate than that of pTKA group (MD = 4.15, 95% CI:2.37–7.25, $P < .05$).
4. Knee Society Knee score: Three studies (N = 298) provided Knee Society Knee score data. Results revealed that rUKA group had a lower Knee Society Knee score than that of pTKA group (MD = −0.54,95% CI:−1.12–0.04, $P < .05$).
5. Knee Society function score: Three studies (N = 298) provided Knee Society function score data. Results revealed that rUKA group had a lower Knee Society Knee score than that of pTKA group (MD = −0.65, 95% CI:−1.25–0.06, $P < .05$).
6. Blood loss: Two studies (N = 226) provided blood loss data. The results of this meta-analysis revealed there is no significant difference between revision of UKAs to TKAs group and pTKA group (MD = 153.36, 95% CI:−182.65–489.78, $P = .37$).

Table 1

Characteristics of the included studies.

Study, year	NO. rUKA/pTKA	Male patients (rUKA/pTKA)	Mean age (rUKA/pTKA)	Follow-up (rUKA/pTKA)	UKA failure reasons	Surgical characteristics of the 2 groups	Quality score
Lunebourg et al 2015	48/48	12/16	71±9/72±12	7±4/7±4	Progressin of arthritis (n=29), aseptic loosening (n=17), wear (n=1)and collapse of the tibial plateau (n=1).	pTKA group : PS prosthesis (n=48). rUKA group : PS prosthesis (n=43),CCK prosthesis (n=5),Stem used (n=35), Augment used (n=14), Autograft used (n=6).	9
Cross et al 2014	49/97	19/47	61.5/58.9	4.56/3.59	Progression of arthritis (n=30), aseptic loosening (n=13), pain in 2 cases wear (n=2), instability (n=1), and pigmented villonodular synovitis (n=1).	pTKA group:NA. rUKA group: Stems only (n=7),Augments only (n=2),Stems and augments (n=8),Constrained bearings (n=4).	8
Jarvenpaa et al 2010	21/28	9/11	74.9±7.4/75.2±7.2	10.5/10.5	Polyethylene wear or breakage (n=15), loosening of the femoral or tibial component (n=4), progression of osteoarthritis (n=1), and severe malalignment of the knee in (n=1).	pTKA group:AMK prosthesis (n=28).rUKA group:AMK prosthesis (n=21),Four bone grafts, six stems and 1 augment were required in eight revision operations.	9
Rancourt et al 2012	63/126	18/36	67.49±10.24/ 66.71±9.77	3.08±1.38/ 3.06±1.16	Progression of arthritis (n=39), loosening of the femoral component (n=8), loosening of the tibial component (n=5), pain of unknown source (n=6), dislocated bearing (n=2), medial collateral ligament failure (n=2), and suspected infection (n=1).	pTKA group : CR prosthesis (n=100), PS prosthesis (n=26). rUKA group:CR prosthesis (n=37), PS prosthesis (n=26),required the use of stems, augments, or bone autografts (n=15).	8
Jonas et al 2014	23/42	7/13	73/68	5.67/5.08	Progression of arthritis (n=9), loosening of the femoral and tibial component (n=6), femoral loosening (n=4),tibial loosening (n=4), unexplained pain (n=3).	pTKA group: CR prosthesis (n=42).rUKA group:CR prosthesis (n=14), PS prosthesis (n=4),with stemmed tibial augment used (n=4), Mobile rotating hinge prosthesis (n=1).	7
Becker et al 2004	28/28	6/6	71.5±6.8/ 71.5±6.6	4.58±1.25/ 4.66±1.08	Aseptic loosening, either at the femoral or tibial site (n=28).	pTKA group:Natural Knee, Sulzer Orthopaedics, Baar, Switzerland (n=28). rUKA group:Natural Knee, Sulzer Orthopaedics, Baar, Switzerland (n=28).	8
Cankaya et al 2016	42/88	14/40	62.1±11.7/ 59.5±11.3	NA	NA	NA	8
Pearse et al 2010	205/34369	NA	NA	NA	NA	pTKA group:NA. rUKA group: Stems (n=45), Wedges (n=29), both (n=8).	8

CCK=Constrained condylar knee prostheses, CR=posterior cruciate retaining total knee prostheses, PS=posterior cruciate stabilizing total knee prostheses, pTKA=primary total knee arthroplasty, rUKA=revision of unicompartmental knee arthroplasty.

7. Length of stay and complications: There was no significant difference in the postoperative complications (MD=0.87, 95% CI:0.44–1.73, $P=.7$) and length of stay (MD=0.34, 95% CI:−0.31–0.99, $P=.31$) between the 2 groups.

4. Discussion

Our meta-analysis revealed that compared with revision of UKAs to TKAs, primary TKAs had a better postoperative ROM, lower (re-)revision rate and better KSS score. There was no significant difference in postoperative complications, blood loss and length of stay between the 2 groups.

For the postoperative (re-)revision rate, results of this meta-analysis revealed that the revision rate of failed UKAs to TKAs was significantly higher than that of the primary TKAs. Data from the New Zealand National Joint Registry revealed that UKAs converted to TKAs had a revision rate of 4 times higher than that of primary TKAs.[15] Data from the Swedish National Joint Registry revealed that the rate of revision of UKAs converted to TKAs in 5 years was 7%, which was 2 times higher than that of primary TKAs.[22] Data from the Australian joint

Table 2

Newcastle-Ottawa scale.

Study	Is the case definition adequate?	Representativeness of the cases	Selection of Controls	Definition of Controls	Comparability of cases and controls on the basis of the design or analysis	Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-Response rate	Scores
Lunebourg et al 2015	1	1	1	1	2	1	1	1	9
Cross et al 2014	1	1	1	1	1	1	1	1	8
Jarvenpaa et al 2010	1	1	1	1	2	1	1	1	9
Rancourt et al 2012	1	1	1	1	1	1	1	1	8
Jonas et al 2014	1	1	1	1	1	1	1	0	7
Becker et al 2004	1	1	1	1	1	1	1	1	8
Cankaya et al 2016	1	1	1	1	1	1	1	1	8
Pearse 2010	1	1	1	1	1	1	1	1	8

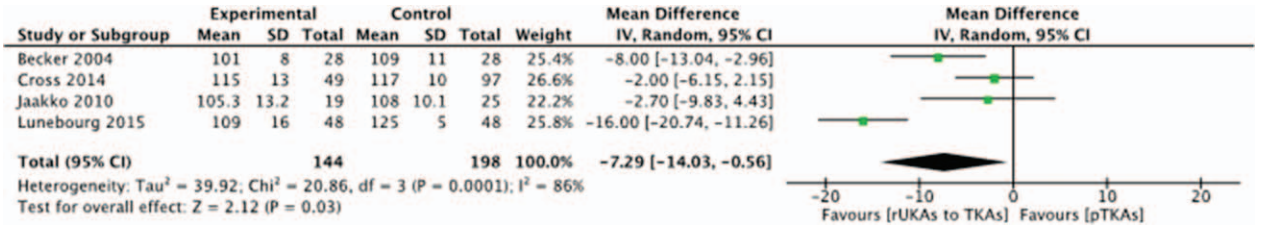

Figure 1. Forest plot analysis of range of motion (ROM).

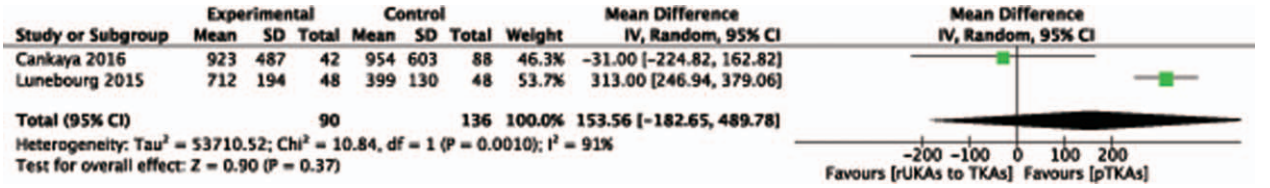

Figure 2. Forest plot analysis of blood loss.

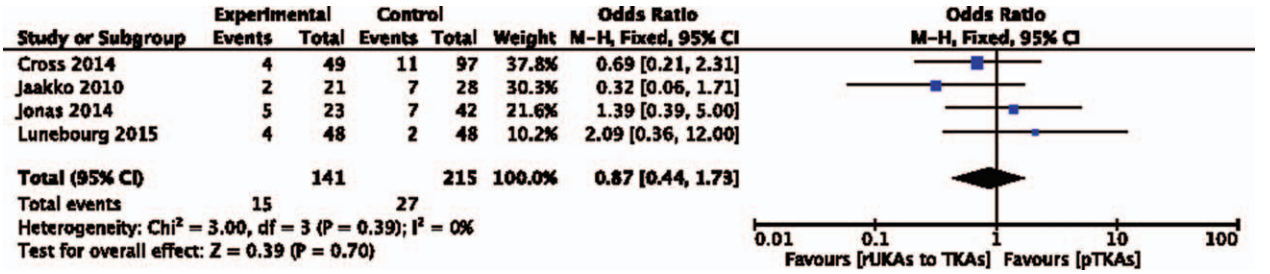

Figure 3. Forest plot analysis of complications.

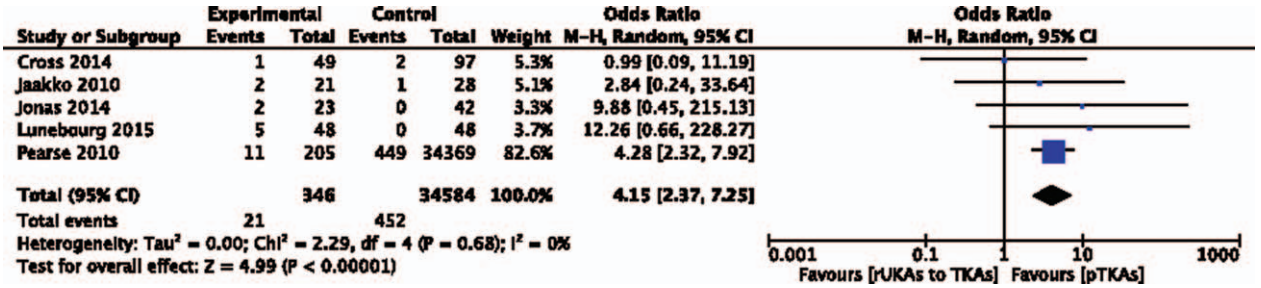

Figure 4. Forest plot analysis of (Re-)Revision rate.

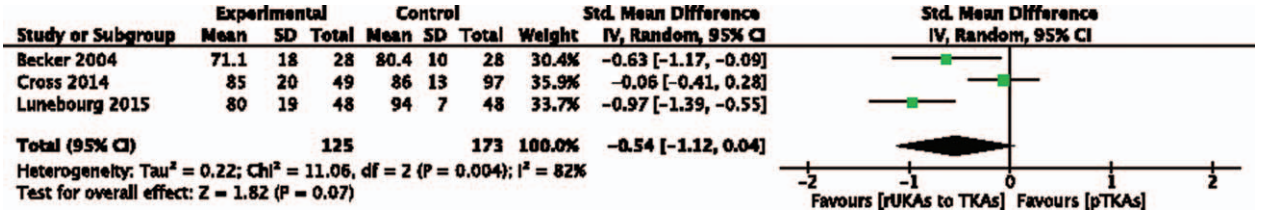

Figure 5. Forest plot analysis of Knee Society Knee score.

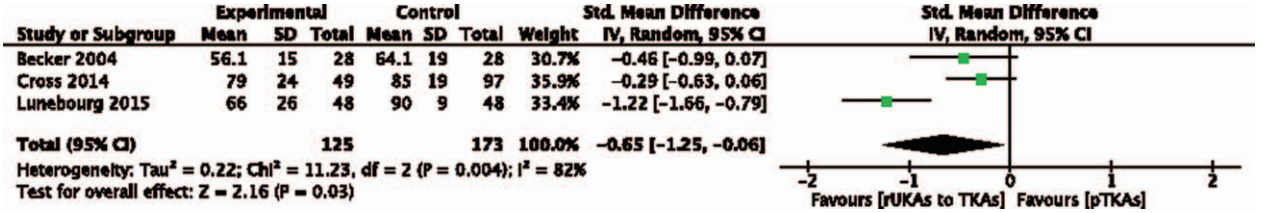

Figure 6. Forest plot analysis of Knee Society function score.

registration center revealed that the rate of revision of UKAs converted to TKAs in 3 years was 10%, which was >2 times higher than that of the primary TKAs. The main reason for the revision was aseptic loosening, with an estimated rate of 46% after UKAs converted to TKAs.[23,24] Lunebourg study revealed that the revision rate of revised UKA group at 5 and 10 years was 7% and 15%, respectively. The results were significantly higher than that of the primary TKA group and close to that of the revision of TKA group.[16] To summarize, the revision rate of revised UKAs to TKAs was significantly higher than that of pTKA.

The controversy about the complexity of UKA conversion to TKA still persists. According to the reported studies, the utilization rate of stem was 2% to 72% and the utilization rate of augment was 3% to 31% in the revision of failed UKAs to TKAs.[5,13,25–30] According to Berend et al,[14] the difficulty of revision of UKAs to TKAs and the use of revision prosthesis are related to UKA failure. When revision occurred due to the progression of arthritis, there was no requirement for stems and augments. In this view, Johnathan et al[31] and Rancourt et al[17] have put forwarded a different opinion. A retrospective matched

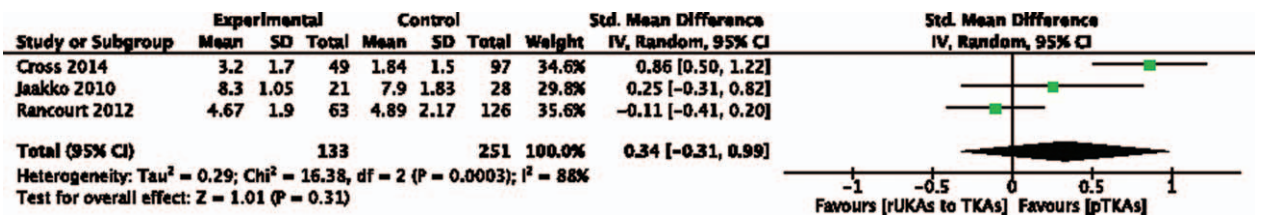

Figure 7. Forest plot analysis of Length of stay.

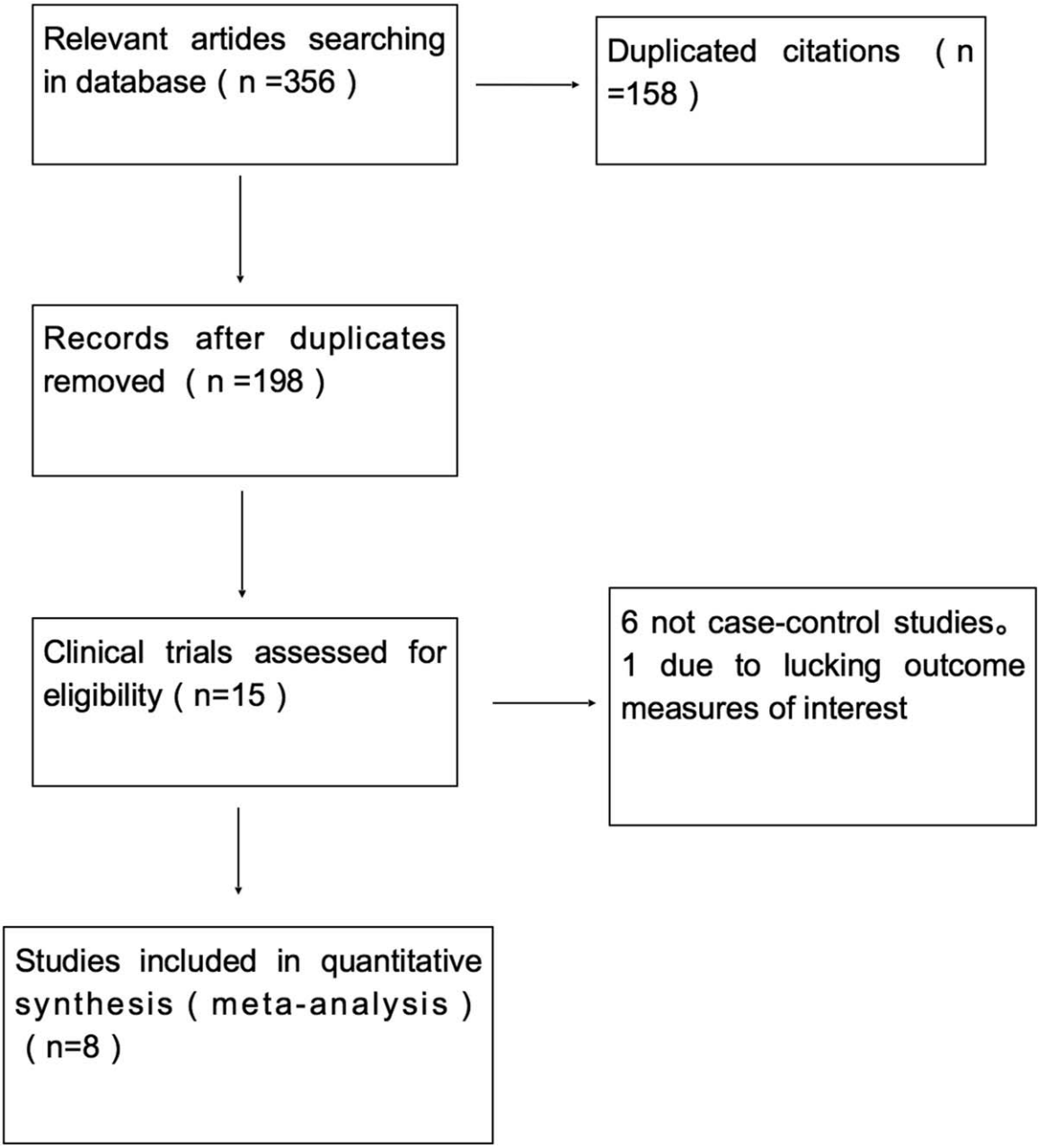

Figure 8. Flow chart of the literature search.

study of Rancourt et al[17] revealed that 61.9% of the UKAs underwent revision for progression of arthritis, and more than half of them required stems, augments, and/or grafts. Furthermore, the bone defects during the revision of failed UKAs are important factors that affect the difficulty of the operation and clinical effect of the patients postoperatively. Two recent studies pointed out that the tibial bone defects were the common problems during the revision of failed UKAs to TKAs, and stems, augments, bone grafts and thicker polyethylene were often required to solve this problem. This in turn significantly increases the difficulty of the operation, with inferior clinical outcomes compared to primary TKAs.[32,33] Sarraf et al[34] predicted that bone defects during the revision of failed UKAs to TKAs might be due to polyethylene thickness. The authors mentioned that the use of polyethylene thickness as a surrogate for tibial bone loss without considering the preservation of joint line, ligamentous stability and use of augments leading to inaccuracy. However, authors believed that large sample data from the UK National Joint Registry can help to reduce the errors caused by these factors. Their statistical results revealed that the average thickness of polyethylene during revision of failed UKAs to TKAs group and primary TKAs group were 12.79 mm and 10.43 mm, respectively, reflecting the degree of tibial bone defects. In addition, the case control study of Becker[18] revealed that the average polyethylene thickness of the revision of failed UKAs to TKAs group and primary TKAs group were 12.4 + 3 mm and 10.3 + 3 mm, which was close to the data of the registry. In summary, the use of stems, augments, grafts and bone defects are

important factors affecting the complexity of revision of a failed UKA to TKA.

Results of this meta-analysis revealed that the KSS scores of primary TKA group were better than that of the revision of UKAs to TKAs group. This may be due to the complexity of operation, greater trauma of operation, more bleeding volume and use of revision prosthesis. This meta-analysis revealed that there was no statistical difference in postoperative complications between the 2 groups. Postoperative complications were the common complications observed after joint arthroplasty, such as wound infection, delayed wound healing, venous thrombosis of the lower limbs, etc. For the amount of bleeding, results revealed no significant difference between the 2 groups. But due to insufficient data, a high-quality and large-scale clinical trials are needed to confirm these findings in future. There was no significant difference in the length of stay between the 2 groups. ROM is an important clinical index for joint function recovery after joint replacement. This meta-analysis revealed that the primary TKA group had better ROM than that of the revised UKAs to TKAs group.

5. Limitations

Firstly, the studies included were only in English in our study, but few studies written in other languages have been missed out. Secondly, the results of the included studies are scattered, limiting the amount of data that can be extracted. Finally, some effective indicators, such as imaging follow-up results, average cost, operation time, polyethylene thickness and other data cannot be extracted, which limited the comprehensiveness of the results. The advantages of this study are clinically instructive and provide a reference for the treatment of clinical cases.

6. Conclusion

Our meta-analysis revealed that compared with primary TKAs, TKAs revised from UKAs had inferior clinical effects in terms of worse postoperative ROM, higher (re-)revision rate, and worse KSS scores. As for the postoperative complications, blood loss and length of stay, there was no more significant difference between the 2 groups.

In summary, the outcome of failed UKAs revision is not as optimistic as expected. The key factors influencing the operation complexity and postoperative clinical effect are the type of UKA prosthesis, mode of failure, bone defect as well as surgical technique. Therefore, it is suggested that before undergoing the revision surgery, each patient should be fully evaluated and prepared on a case by case basis.

Author contributions

Conceptualization: Zhaohui Liu and Weiguo Wang.
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Investigation: Wei Zuo.
Methodology: Wei Zuo and Qidong Zhang.
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Writing – original draft: Wei Zuo.
Writing – review & editing: WanShou Guo.

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