MEDS Clinical Medicine (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/medsc.2024.050316
ISSN 2616-1907 Vol. 5 Num. 3

Different surgical treatment modalities for single-compartment knee osteoarthritis: A Bayesian network meta-analysis of randomized controlled trials

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Keywords: Single compartment knee osteoarthritis, high tibial osteotomy, unicompartmental knee arthroplasty, total knee arthroplasty, network meta-analysis

Abstract: The surgical treatment of single-compartment knee osteoarthritis remains controversial, so we used a network meta-analysis based on Bayesian theory for total knee arthroplasty (TKA), Unicompartmental Knee Arthroplasty (UKA), and high tibia osteotomy (HTO) was evaluated for the efficacy of these three surgical techniques in the treatment of single-compartment knee osteoarthritis.The method we used was a computerized search of the Pubmed, CNKI, The Cochrane Library databases. Retrieval of randomized controlled trials of TKA, UKA, and HTO for unicompartmental knee osteoarthritis. Two independent authors were used for data extraction and literature quality evaluation, and the Knee Society Score (KSS), KSS(functional), revision rate, and complication rate were used as evaluation indicators. Stata, Revman, JAGS, and the gemtc package, which is based on R, were all used to carry out the Bayesian network meta-analysis. After screening, a total of 1438 patients from nine andomized controled trials were included in the analysis. The literature was retrieved from 2158 papers. The SUCRA value of KSS from high to low was: HTO, TKA, UKA, the SUCRA value of KSS (functional) from high to low was: HTO, UKA, TKA, the SUCRA value of the revision rate from low to high: HTO, UKA, TKA, and the SUCRA value of the complication rate from low to high was: HTO, TKA, UKA. Between the three surgical approaches, there were no significant differences in postoperative KSS, KSS (functional), revision rates, or complication rates.

1. Introduction

The most prevalent chronic joint disease, knee osteoarthritis (KOA), initially affects only the unilateral compartment and is characterized by secondary bone growth and degenerative changes in the articular cartilage [1]. Osteoarthritis can have multiple joint degeneration and pathological changes, and subchondral bone changes and osteophyte formation are often considered to be the hallmark of osteoarthritis, which usually occurs in late OA[2], The primary clinical symptoms of KOA are pain and knee joint dysfunction, both of which have a negative impact on the patients' quality of life. The

medial compartment, lateral compartment, and patellofemoral compartment of the knee joint can all be negatively impacted by KOA, and approximately one-third of patients accumulate only a single compartment, usually more susceptible to medial compartments than lateral compartments[3]. The three primary surgical treatments for treating unicompartmental KOA are TKA, UKA, HTO. All of these surgeries aim to relieve pain, restore function, and enhance quality of life. The indications for these three surgical treatment options overlap considerably, as well as their respective indications. Therefore, for specific patients, different surgical options are faced. Past studies have focused on direct comparisons of the two surgical options, and results from direct or indirect comparisons between the three interventions have been lacking. Therefore, in this study, we compared three surgical interventions for the treatment of singlecompartment KOA simultaneously using a network metaanalysis based on a Bayesian theoretical framework to analyze their postoperative efficacy as well as postoperative revision and complication rates [4]. The purpose of this research is to provide clinicians with a guideline when choosing a treatment options for their patients.

2. Methods

2.1. Search strategy

Up to March 7, 2023, we search for controlled randomized trials on KOA in the databases of Pubmed, CNKI, and The Cochrane Library.

2.2. Study selection

The inclusion criteria: (1) All research studies included in this NMA were RCTs; (2)The participants in this research were all over 60 years old on average and all had knee osteoarth ritis; (3)two of the three surgical treatment modalities (TKA, UKA, HTO) were included in the RCT; (4) All had follow-up outcomes, and the period of follow-up was at least 6 months.The exclusion criteria: (1)non-randomized controlled trials; (2)patients in the study were diagnosed with double-compartment knee osteoarthritis; (3)KSS , KSS(functional), revision rate, complication rate, etc. were not included in the outcome measures of the study.

2.3. Data extraction and quality assessment

The data extraction and quality evaluation in the original article were doneindependently by two researches. As outcome markers, we selected the KSS, KSS (functional), revision rate, and complication rate in order to compare the prognosis of the three surgical procedures. The extracted data included:(1)authors;(2)time of publication;(3)the location of the study;(4)sample size;(5)average age;(6)gender;(7)mean follow-up time;(8)outcome measures. To evaluate the level of quality of the collected literature, two independent researchers utilized the Cochrane Risk of Bias Assessment tool[5]. Review Manager 5.4 software is used to complete the risk assessment. Each study completed a risk assessment, which included factors such as high risk, unknown risk, and low risk. We got in touch with the author of the original paper to request redeterminations for several items that we determined from the original text to have ambiguous risk assessments.

2.4. Statistical analysis

We used the odds ratio (OR) and its 95% confidence interval (CI) for the dichotomous variables. The 95% CI and mean difference (MD) were used for continuous variables.For our Bayesian network meta-analysis, we used Stata software, Revman software, JAGS software and R software, gemtc

package. We used Stata 17.0 to make a network evidence map. For sample simulations and calculations, we used a Bayesian Markov Chain Monte Carlo (MCMC) random effects model. The convergence diagnostic results were plotted as convergence diagnostic plots, trajectory plots and density maps. The potential scale seen factor (PSRF), which was limited to 1–1.05 for a good level of convergence, was used to assess the iterative convergence. For the dichotomous variables of each treatment, ORs and their 95% CIs were calculated, and 95% CIs that did not include 1 were considered to be statistically significant. The 95% CIs that did not include 0 for the MD of continuous variables and their 95% CIs were considered statistically significant. The gemtc package in R was used to calculate the relative comparison results between various interventions and draw the ranking table, and further determine the values for the cumulative probability ranking plot (SUCRA) and relative ranking. The gemtc programs were used to determine the means under the random effects and fixed effects models and test for homogeneity in the literature.If all points are within the 95% confidence interval, homogeneity is good. For net meta-analysis, the consistency model was chosen if the difference between direct comparison outcomes and indirect outcomes of comparison was not statistically significant ($p > 0.05$), and the inconsistency model was used otherwise. The three intervention nodes in this study did not form a closed loop, no consistency test was required, for heterogeneity testing, $I^2<50\%$, considered to be heterogeneous, $I^2\geq50\%$ indicated heterogeneity, the source of heterogeneity needs to be analyzed, and if it is still not possible to eliminate and maintain clinical consistency, a random-effects model is used. Additionally, sensitivity analyses were performed to find out if the outcomes of the analysis would change if certain pieces of literature were excluded from assessment. For outcomes with ≥9 included studies, we assessed publication bias using funnel plots.

3. Results

3.1. Search selection and characteristics of included study

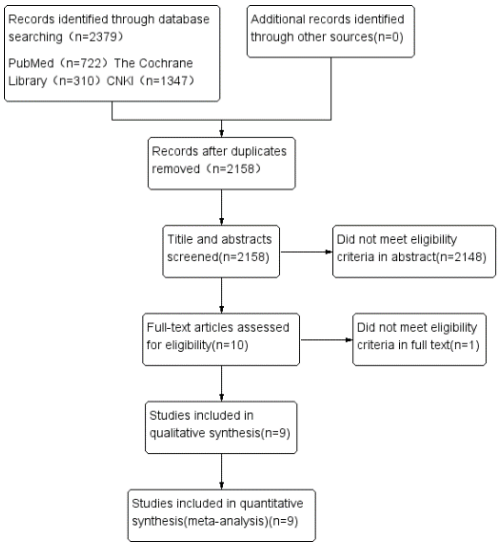


Figure 1: Flowchart of trail selection.

We searched three databases and retrieved a total of 2379 papers, and then imported all retrieved documents into EndnoteX9 software, excluding 221 duplicate papers, excluding 2148 papers after reading the title and abstract, and identifying 10 literature that met the topic of the paper. After reading the content of the paper and outcome measures, one paper was excluded, and 1438 patients from nine studies were finally identified for inclusion in the study[6-14] (Figure1). There were no statistically

significant variations in sample size, mean age, or sex ratio between the two patient groups prior to surgical therapy (Table 1).

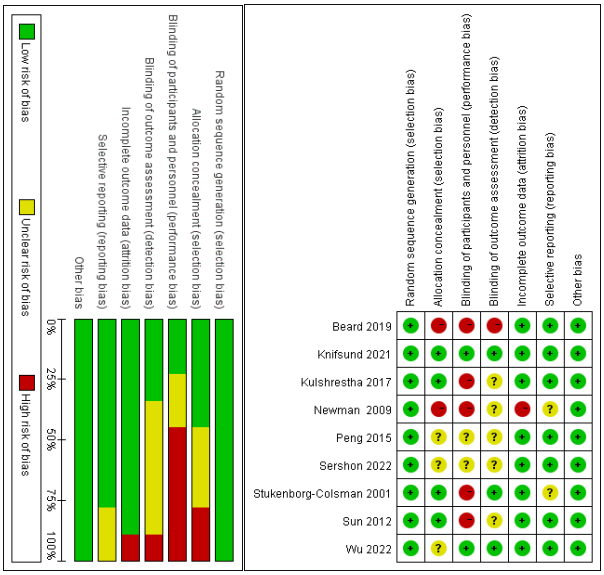


Figure 1: Risk of bias summary.

Table 1: Characteristics of data extracted from the included studies.

Study (year)	Location	Treatment	Sample size	Mean age(year)	Sex (Woman, %)	Mean follow-up(months)	Outcomes assessed
Stukenborg-Colsman (2001)	Germany	UKA	30	67	73.3	90	KSS, KSS(functional), renovations, complications
		HTO	32	67	40.6	90	
Newman (2009)	Britain	UKA	52	69.6	55.8	180	renovations, complications
		TKA	50	69.8	52	180	
Sun (2012)	China	UKA	28	60	64.3	52	renovations, complications
		TKA	28	61	32.1	52	
Peng (2015)	China	UKA	50	66.2	72	26	KSS, KSS(functional), renovations, complications
		TKA	50	66.5	74	26	
Kulshrestha (2017)	India	UKA	80	59.72	37.5	24	complications
		TKA	80	62.19	32.5	24	
Beard (2019)	Britain	UKA	264	65.2	42	60	KSS, KSS(functional), complications
		TKA	264	64.7	42	60	
Knifsund (2021)	Finland	UKA	72	63.3	54.2	24	renovations, complications
		TKA	71	62.9	57.7	24	
Sershon (2022)	America	UKA	57	65.5	52.6	6	KSS, complications
		TKA	50	66.9	62	6	
Wu (2022)	China	UKA	120	63	-	38.7	KSS(functional), renovations, complications
		TKA	60	64	-	38.7	

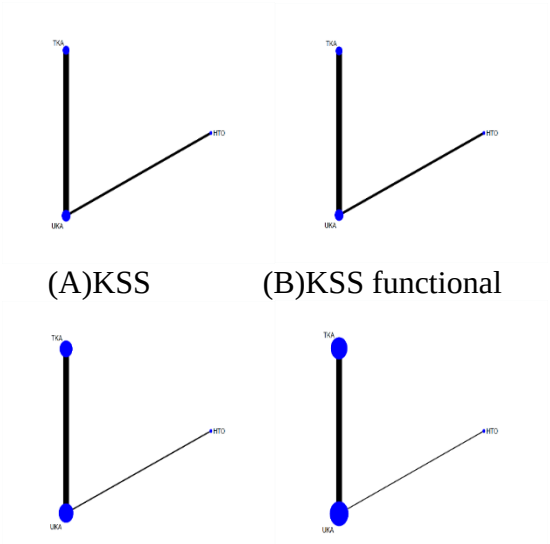
3.2. Risk of bias assessment

Figure 2 displays the findings of the risk of bias assessment. All nine studies were regarded as low-risk because they all used a random assignment method and reported it. Two of the studies failed to determine the random sequence generation and allocation strategies from the original literature, which made them high-risk in terms of allocation concealment[9,13]. For double-blind, patients who underwent surgery were considered high risk in five of the five studies [9,10,12-14] due to the specificity of the surgery. One study was considered to be at high risk in terms of outcome assessment [9], one study was identified as high risk with incomplete data at postoperative follow-up[13], and was considered uncertain or low risk of reporting and other biases.

3.3. Results of network meta-analysis

First, we generated a network evidence map using Stata software, in which three nodes represent three interventions (UKA, TKA, HTO), and the connections between nodes are weighted according to the number of studies of directly compared interventions. Larger nodes indicate a larger number of participants in the corresponding direct comparison, and thicker connections between nodes indicate a greater number of corresponding pairwise comparisons. A network of evidence plots comparing the three interventions with each other is shown in Figure 3. Subsequently, we obtained convergence diagnostic data and generated trace plots, density plots, and convergence diagnostic plots based on these results.

3.3.1. KSS



(A)KSS (B)KSS functional

(C) Renovation rate (D) Complication rate

Figure 2: Network diagram of different interventions

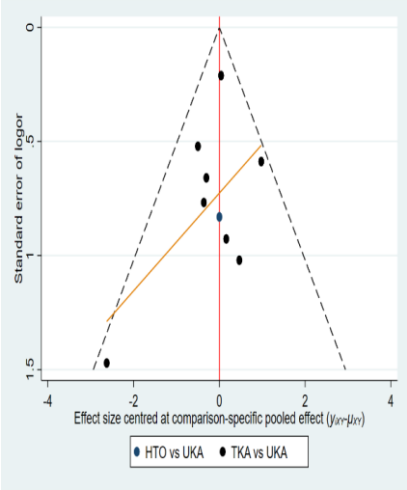


Figure 4: Funnel plot of complication rate

A total of four studies reported KSS. Between patients who underwent UKA and those who underwent TKA or HTO, there was no statistically significant difference in postoperative KSS, and consistent with the results of the network meta-analysis (Table 2). The probability of high to low KSS is: HTO (0.5843850), TKA (0.5724475), UKA (0.3431675). This result indicates that the order of KSS from highest to lowest may be: HTO, TKA, UKA.

Table 2: The league table between the various interventions (KSS)

	UKA	**TKA**	**HTO**
UKA	**UKA**	0.90(-2.98, 5.99)	2.11(-12.48, 16.95)
TKA	-0.90(-5.99, 2.98)	**TKA**	1.11(-14.43, 16.37)
HTO	-2.11(-16.96, 12.48)	-1.11(-16.37, 14.32)	**HTO**

3.3.2. KSS (Functional)

A total of four studies reported KSS (functional). Between patients who underwent UKA and those who underwent TKA or HTO, there was no statistically significant difference in postoperative KSS (functional), consistent with the results of the network meta-analysis (Table 3). The probability of KSS function score from high to low of the three interventions is HTO (0.8891275), UKA (0.4751475), TKA (0.1357250), and the results show that the order of KSS (functional) from high to low may be HTO, UKA, TKA.

Table 3: The league table between the various interventions (KSS functional)

	UKA	**TKA**	**HTO**
UKA	**UKA**	-1.32(-5.73, 3.20)	12.01(-8.71, 32.10)
TKA	1.32(-3.20, 5.73)	**TKA**	13.32(-7.77, 33.85)
HTO	-12.01(-32.10, 8.71)	-13.32(-33.85, 7.77)	**HTO**

3.3.3. Renovation rate

A total of seven studies reported revision rates. Between patients who underwent UKA and those who underwent TKA or HTO, there was no statistically significant difference in postoperative revision rates, consistent with the results of the network meta-analysis (Table 4).The probability of

renovation rate from low to high of the three interventions is HTO (0.2969750), UKA (0.4719625), TKA (0.7310625), and the results show that the order of renovation rate from low to high may be HTO, UKA, TKA.

Table 4: The league table between the various interventions (renovation rate)

	UKA	TKA	HTO
UKA	**UKA**	0.69(0.13, 3.06)	1.73(0.05, 51.24)
TKA	1.45(0.33, 7.69)	**TKA**	2.51(0.06, 116.98)
HTO	0.58(0.02, 18.3)	0.4(0.01, 16)	**HTO**

3.3.4. Complication rate

A total of nine studies reported revision rates. Between patients who underwent UKA and those who underwent TKA or HTO, there was no statistically significant difference in postoperative complication rates, consistent with the results of the network meta-analysis (Table 5).The probability of complication rates of the three interventions from low to high is HTO (0.1024900), TKA (0.4436275), and UKA (0.9538825), which indicates that the order of complication rate from low to high may be HTO, TKA, UKA. As shown in Figure 4, the comparison-correction funnel plot showed that the inclusion of articles containing complication rates was not clearly at publication bias (Figure 4).

Table 5: The league table between the various interventions (complication rate)

	UKA	TKA	HTO
UKA	**UKA**	1.88(0.91, 4.87)	6.55(0.57, 112.66)
TKA	0.53(0.21, 1.1)	**TKA**	3.47(0.24, 62.4)
HTO	0.15(0.01, 1.76)	0.29(0.02, 4.13)	**HTO**

4. Discussion

For patients with end-stage knee osteoarthritis, the clinical prognosis is a key concern for clinicians when faced with the surgeon's choice of surgical modality. Physicians who prefer to perform UKA surgery point to the advantages of UKA over TKA as having increased range of motion after surgery, lower incidence of joint stiffness, shorter recovery time, fewer hospital stays, and higher patient satisfaction[15]. Migliorini's meta-analysis comparing UKA with TKA found that while UKA had a lower prosthesis survival rate, it had a better clinical prognosis and performed better than TKA in terms of KSS (functional) and knee range of motion[16]. Compared with UKA, HTO has the advantage of preserving the bone mass of the compartment as well as joint cartilage, so HTO can recover mobility earlier, with better joint mobility for younger patients. UKA, on the other hand, is more suited for senior people since it requires less time for recovery and leads to a quicker return to function. A meta-analysis by Santoso noted that long-term follow-up outcomes at UKA improved due to rigorous surgical indications and patient selection, with satisfactory results for both regimens[17]. In a meta-analysis of Fu comparing UKA with HTO, no difference in KSS was observed, and there was no statistically significant rate of postoperative revision or complication between the two groups, and reliable results were shown for both procedures[18]. So for HTO and UKA, we cannot conclude which method is superior.In this review, KSS, KSS(functional), revision rate, and complication rate were selected as the outcomes of this review to compare the prognosis of the three surgical interventions. Our results showed that HTO outperformed UKA and TKA in terms of postoperative KSS, KSS(functional), revision rate and complication rate, while UKA had higher KSS(functional) and lower revision rate than TKA, while TKA had higher KSS and lower

complication rate than UKA. There were no significant differences in any of these results.However, this study also has limitations, such as: (1) Only nine articles from randomized controlled trials were examined because of the ethical issues associated with such research and the specificity of surgical procedures. (2) The majority of the included studies compared UKA and TKA, although the absence of direct comparisons between HTO and TKA had some effect on the study's findings. (3)Although the cases included in this study only accumulated unilateral compartments, due to the different indications of the three surgeries, surgeons will have biases in the selection of patients, which will affect the final results.

5. Conclusion

In conclusion, our present network meta-analysis shows that there is no statistically significant difference in postoperative KSS, KSS (functional), revision rate, or complication rate across surgical therapies for unicompartmental knee osteoarthritis.

References

[1] Nelson A E. Osteoarthritis year in review 2017: clinical [J]. Osteoarthritis Cartilage, 2018, 26(3): 319-325.

[2] Alliston T, Hernandez C J, Findlay D M, et al. Bone marrow lesions in osteoarthritis: What lies beneath [J]. J Orthop Res, 2018, 36(7): 1818-1825.

[3] Ledingham J, Regan M, Jones A, et al. Radiographic patterns and associations of osteoarthritis of the knee in patients referred to hospital [J]. Ann Rheum Dis, 1993, 52(7): 520-526.

[4] Senn S, Gavini F, Magrez D, et al. Issues in performing a network meta-analysis [J]. Stat Methods Med Res, 2013, 22(2): 169-189.

[5] Higgins J P, Altman D G, Gøtzsche P C, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials [J]. Bmj, 2011, 343(d5928.

[6] Wu L P, Mayr H O, Zhang X, et al. Knee Scores of Patients with Non-Lateral Compartmental Knee Osteoarthritis Undergoing Mobile, Fixed-Bearing Unicompartmental Knee and Total Knee Arthroplasties: A Randomized Controlled Trial [J]. Orthop Surg, 2022, 14(1): 73-87.

[7] Sershon R A, Fricka K B, Hamilton W G, et al. Early Results of a Randomized Controlled Trial of Partial Versus Total Knee Arthroplasty [J]. J Arthroplasty, 2022, 37(6s): S94-s97.

[8] Knifsund J, Niinimaki T, Nurmi H, et al. Functional results of total-knee arthroplasty versus medial unicompartmental arthroplasty: two-year results of a randomised, assessor-blinded multicentre trial [J]. BMJ Open, 2021, 11(6): e046731.

[9] Beard D J, Davies L J, Cook J A, et al. The clinical and cost-effectiveness of total versus partial knee replacement in patients with medial compartment osteoarthritis (TOPKAT): 5-year outcomes of a randomised controlled trial [J]. Lancet, 2019, 394(10200): 746-756.

[10] Kulshrestha V, Datta B, Kumar S, et al. Outcome of Unicondylar Knee Arthroplasty vs Total Knee Arthroplasty for Early Medial Compartment Arthritis: A Randomized Study [J]. J Arthroplasty, 2017, 32(5): 1460-1469.

[11] Peng Song, Xu Boyong, Cao Li. Comparison of knee scores in patients with monocondylar replacement versus total knee replacement: a randomized controlled trial [J]. Chinese Tissue Engineering Research, 2015, 19(48): 7724-7730.

[12] Sun P F, Jia Y H. Mobile bearing UKA compared to fixed bearing TKA: a randomized prospective study [J]. Knee, 2012, 19(2): 103-106.

[13] Newman J, Pydisetty R V, Ackroyd C. Unicompartmental or total knee replacement: the 15-year results of a prospective randomised controlled trial [J]. J Bone Joint Surg Br, 2009, 91(1): 52-57.

[14] Stukenborg-Colsman C, Wirth C J, Lazovic D, et al. High tibial osteotomy versus unicompartmental joint replacement in unicompartmental knee joint osteoarthritis: 7-10-year follow-up prospective randomised study [J]. Knee, 2001, 8(3): 187-194.

[15] Chalmers B P, Mehrotra K G, Sierra R J, et al. Reliable outcomes and survivorship of unicompartmental knee arthroplasty for isolated compartment osteonecrosis [J]. Bone Joint J, 2018, 100-b(4): 450-454.

[16] Migliorini F, Tingart M, Niewiera M, et al. Unicompartmental versus total knee arthroplasty for knee osteoarthritis [J]. Eur J Orthop Surg Traumatol, 2019, 29(4): 947-955.

[17] Santoso M B, Wu L. Unicompartmental knee arthroplasty, is it superior to high tibial osteotomy in treating unicompartmental osteoarthritis? A meta-analysis and systemic review [J]. J Orthop Surg Res, 2017, 12(1): 50.

[18] Fu D, Li G, Chen K, et al. Comparison of high tibial osteotomy and unicompartmental knee arthroplasty in the treatment of unicompartmental osteoarthritis: a meta-analysis [J]. J Arthroplasty, 2013, 28(5): 759-765.