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GENERAL REVIEW • KNEE - ARTHROPLASTY

Is unicompartmental knee arthroplasty (UKA) superior to total knee arthroplasty (TKA)? A systematic review and meta-analysis of randomized controlled trial

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Abstract
Objective To compare clinical outcomes of unicompartmental knee arthroplasty (UKA) versus total knee arthroplasty (TKA).
Methods A systematic review and meta-regression to compare postoperative outcomes of pain VAS, knee function score, range of motion, complications and revision surgery rates between UKA and TKA were conducted. Relevant randomized controlled trials were identified from MEDLINE and Scopus from inception to August 29, 2014.
Results Three of 1056 studies were eligible; two, three, two, three and three studies were included in pooling of pain visual analog score (VAS), Knee Society Score (KSS) and Bristol Knee Score (BKS), maximum knee flexion, postoperative complications (aseptic loosening, progressive degenerative joint disease of lateral compartment, bearing dislocation, DVT, fractures and infection) and revision rates, respectively. The unstandardized mean difference (UMD) of the function scores (KSS, BS) for UKA was 1.62 (95 % CI −1.17, 4.42) better than TKA and for pain score was 0.1 (95 % CI −3.54, 3.73) higher than TKA, but both without statistical significance. UKA was more likely to show higher mean maximum knee flexion with a UMD of 1.88 (95 % CI −0.54, 4.30) when compared to TKA, but was also not statistically significant. UKA had a statistically significant lower chance of postoperative complications by 0.35 U (95 % CI 0.12, 0.98) when compared to TKA, but had higher revision rates than TKA with a value of 5.36 (95 % CI 1.06, 27.08).
Conclusion In short-term outcomes (5 years or less, with follow-up of 0–5 years), TKA had higher postoperative complications than UKA, but had lower revision rates. There was only one study that reported long-term survivorship (more than 5 years, with follow-up of 5–15 years). Further research that assesses long-term survivorship is necessary to better evaluate UKA and TKA in the treatment of unicompartmental knee osteoarthritis.

Keywords Unicompartmental knee arthroplasty · Total knee arthroplasty · Systematic review · Meta-regression

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Introduction

The best treatment options for patients with medial compartment osteoarthritis (OA) of the knee [18] are still controversial. Total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA) are both utilized to treat OA of the knee. TKA has long been considered the gold standard of operative intervention for knee arthrosis due to demonstrated predictability, durability and effectiveness in the treatment of pain and restoration of function [1, 4, 7, 9, 16]. Many authors have shown good long-term survivorship following UKA as well as better kinematics [3, 11, 13], pain scores, function, lower complication rates and increased longevity [16, 26, 27] in OA knee. Some studies report UKA results that are comparable to those of TKA [24]. The debate of whether UKA offers clinical and longevity advantages over TKA for isolated symptomatic OA of the knee has continued to generate substantial controversy in the orthopedic community. Randomized controlled trials (RCTs) represent the best study design to compare UKA with TKA. However, no consistent results have been shown in these published randomized trials [5, 20, 23]. To the best of our knowledge, one meta-analysis [28] that compares UKA with TKA has been published over the past few years that pooled only one RCT study [19, 20] with 6 other prospective cohort studies [2, 6, 12, 15, 17, 27], and found that there was no clinically relevant or statistically significant improvement in UKA when compared to TKA. However, this meta-analysis did not consider sources of heterogeneity (e.g., preoperative range of motion, age, sex, and body mass index), and publication bias was not assessed. Moreover, other RCTs [5, 23, 25] have since been published. Therefore, a meta-analysis and systematic review of randomized clinical studies were performed to compare UKA and TKA with the aim of updating current data regarding knee pain, knee scores, function and complications.

Materials and methods

MEDLINE and Scopus databases were used for identifying relevant studies published in English since the date of inception to September 11, 2014. The PubMed and Scopus search engines were used to locate studies with following search terms: UKA and TKA and clinical trial. Search strategies for MEDLINE and Scopus are described in detail in the appendix. References from the reference lists of included trials and previous systematic reviews were also explored.

Selection of studies

Identified studies were first selected based on titles and abstracts by two independent authors (J.K. and A.A.). Full papers were retrieved if a decision could not be made from the abstracts. Disagreements were resolved by consensus and discussion with a third party (S.M.). Reasons for ineligibility or exclusion of studies were recorded and described.

Inclusion criteria

Randomized controlled trials, quasi-experimental designs and prospective comparative studies that compared clinical outcomes between UKA and TKA were eligible if they met the following criteria:

- Compared clinical outcomes between UKA and TKA.
- Compared at least one of following outcomes: knee visual analog pain score (VAS), knee range of motion (ROM) in flexion and extension, Knee Society Score (KSS) and Knee Society Function Score (FS), Bristol Knee Score (BKS), early postoperative complications [aseptic loosening, progressive degenerative joint disease of lateral compartment, bearing dislocation, infection, deep vein thrombosis (DVT), fracture] and revision surgery.
- Had sufficient data to extract and pool, i.e., the reported mean, standard deviation (SD), the number of subjects according to treatments for continuous outcomes, and the number of patients according to the treatment for dichotomous outcomes.

When eligible papers had insufficient information, we contacted authors by e-mail (up to three consecutive e-mails if there was no reply) for additional information. If authors did not provide additional data, the study was excluded from the review.

Data extraction

Two reviewers (J.K. and A.A.) independently performed data extraction using standardized data extraction forms. General characteristics of the study [i.e., mean age, gender, body mass index (BMI), mean follow-up time, range of motion (ROM) and functional scores (KSS, BKS) at baseline] were extracted. The number of subjects, mean and SD of continuous outcomes (i.e., knee ROM), knee functional scores (KSS, BKS) between the groups were extracted. Cross-tabulated frequencies between treatment and all dichotomous outcomes (early postoperative complications and revisions) were also extracted. Any disagreements were resolved by discussion and consensus with a third party (S.M.).

Risk of bias assessment

Two authors (J.K. and A.A.) independently assessed the risk of bias for each study following suggestion in the PRISMA guideline [14]. Six domains were assessed, which included sequence generation, allocation concealment, blinding (participant, personnel and outcome assessors), incomplete outcome data, selective outcome reporting and other sources of bias. Disagreements between two authors were resolved by consensus and discussion with a third party (S.M.). Level of agreement for each domain and the overall domains were assessed using the Kappa statistics.

Outcomes

The outcomes of interests included knee pain visual analog scores (VAS), Knee Society scores for pain, knee ROM, Knee Society scores for function, Bristol knee score, rates of early postoperative complications and revision. These outcomes were measured as reported in the original studies, which were by VAS and Knee Society pain scores, goniometer measurement of knee ROM for maximum knee flexion; Knee Society Score (KSS) and (BKS) for function. For knee pain VAS and KSS, lower values are equivalent to better outcomes. For knee ROM, higher values are equivalent to better outcomes. For the functional scores including KSS (0–100) and BKS (0–100) scores, higher scores reflect better function. Early postoperative complications (aseptic loosening, progressive degenerative joint disease of lateral compartment, bearing dislocation, infection, deep vein thrombosis, fracture) and revision were considered.

Statistical methods

For continuous outcomes (i.e., knee VAS, ROM, KSS and BKS), the mean difference between UKA and TKA was estimated for each study. Unstandardized mean difference was applied for pooling outcomes across studies. Before pooling, intervention effects were assessed on whether they varied or were heterogeneous across included studies. Heterogeneity of mean differences was checked using the Q statistic, and the degree of heterogeneity was also quantified using the I^2 statistic. If heterogeneity was significant or $I^2 > 25$ %, the UMD was estimated using a random effects model, otherwise a fixed effects model was applied.

For dichotomous outcomes, the odds ratio (OR) for complications (aseptic loosening, progressive degenerative joint disease of lateral compartment, bearing dislocation, infection, DVT and fracture) and for revision rates was estimated for each study. Heterogeneity of OR across studies was assessed using the same method as mentioned previously. If heterogeneity was present, the random effects by Dersimonian and Laird method were applied for pooling OR; otherwise, the fixed effects by inverse variance method was applied.

Meta-regression was applied for exploring the cause of heterogeneity by fitting a covariable [e.g., mean age, BMI, follow-up time, type of surgery (unilateral or bilateral), preoperative VAS, ROM and percentage of female] in the meta-regression model. Subgroup or sensitivity analysis was then performed according to the results of meta-regression. Publication bias was assessed using contour funnel plots [21, 22] and Egger tests [8]. Asymmetry of the funnel plot might be due to missing data in some studies, in which the results that were negative might not have been published and thus could not be identified. The metatrim and fill method was used to estimate the number of studies that might be missing and to adjust the pooled estimate [1]. All analyses were performed using STATA version 13.0. p value < 0.05 was considered statistically significant, except for the test of heterogeneity where <0.10 was used.

Results

Eighty-three and 1026 studies were identified from MEDLINE and Scopus respectively, (Fig. 1); 55 studies were duplicates, leaving 1054 studies to review titles and abstracts. Of these, four RCT studies [5, 20, 23, 25] were reviewed and data were extracted. Characteristics of the four studies [5, 20, 23, 25] are described in Table 1. Two [20, 25] of the four studies were performed at the same center and the same time period, but difference outcome of interest. Knee function was reported using the KSS in two studies [5, 23] and BKS in one study [20]. Two studies [23, 25] reported postoperative ROM for maximum knee flexion. Knee pain was reported using the VAS in one study [25] and KSS in one study [5]. (composite outcomes of DVT, infection and fracture) were reported in three studies [5, 20, 23], and revision knee arthroplasty in three studies [5, 20, 23]. Mean age, BMI and mean follow-up of participants varied from 60.5 to 73 years, 30 years and 4–5 years, respectively. Percentages of female gender ranged from 44 to 66 %. All four studies were posterior stabilized TKA implants. Three studies [5, 20, 25] included fixed-bearing UKA implants, whereas only one study [23] used a mobile-bearing UKA implant.

Risk of bias in included studies

Risk of bias is described in Table 2.

Outcome

Knee function, pain and range of motion (ROM)

Knee function Three studies reported mean function scores (two studies were KSS, and one study was BKS) between UKA and TKA groups with 112 and 114 patients. The pooled UMD varied moderately across studies (Chi-square = 4.17, $df = 2$, $p = 0.124$, $I^2 = 52.1$ %) were 1.62 (95 % CI −1.17, 4.42), indicating that the UKA group had function scores better than the TKA group, but without statistically significant (Fig. 2). None of the covariables could explain the heterogeneity. There was no evidence of publication bias on Egger's test or contour funnel plot (coefficient = 5.72, SE = 2.87, $p = 0.296$).

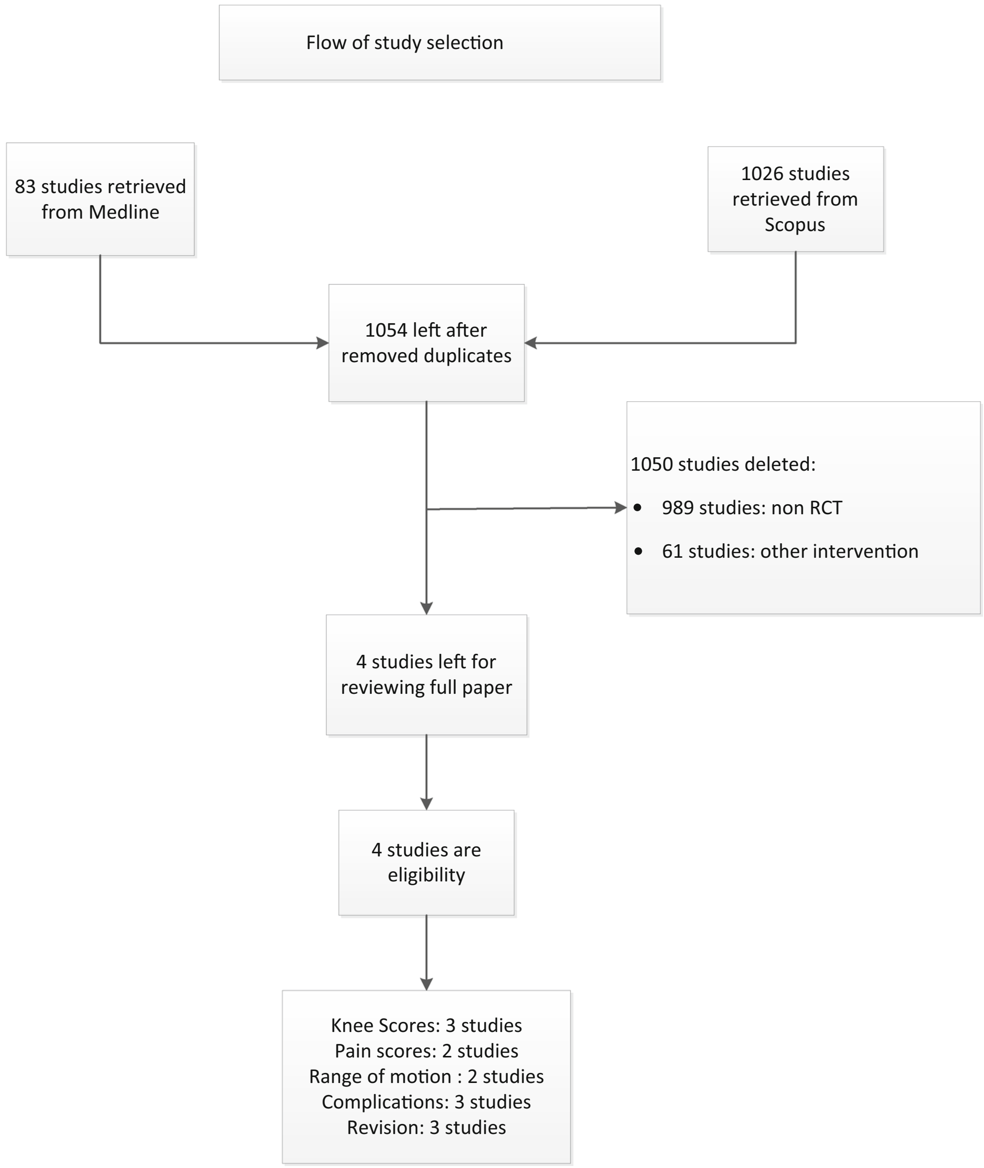

Fig. 1 Flow of study selection

Knee pain Two studies with 84 and 86 patients, respectively, compared mean pain scores (one study was VAS, and another one study was KSS) between UKA and TKA groups (Table 3). Mean difference varied highly across studies (Chi-square = 5.57, $df = 1$, $p = 0.018$, I2 = 82.1 %) with an UMD of 0.1 (95 % CI −3.54, 3.73), indicating that the UKA group had no statistically significant difference of pain when compared to the TKA group (Fig. 2).

Postoperative knee range of motion for maximum knee flexion Two studies with 78 and 80 patients compared the mean values of maximum knee flexion between UKA and TKA (Table 3). Mean difference varied highly across studies (Chi-square = 18.87, $df = 1$, $p < 0.05$, $I^2 = 94.7$ %) with an UMD of 3.56 (95 % CI −.52, 14.63). The mean difference of maximum knee flexion was 3.56°, but the two techniques did not show a significant difference (Fig. 2).

Complication and revision outcomes

Three studies reported early postoperative complications and revision surgery within the UKA and TKA groups (Table 4). Risk of complications was lower in the UKA group (Chi-square = 0.22, $df = 2$, $p = 0.897$, $I^2 = 0$ %, Fig. 3) with a pooled RR of 0.39 (95 % CI 0.16, 1.00) when compared to the TKA group, indicating that the chance of having postoperative complications was lower by approximately 60 percent in the UKA group when compared to the TKA group. However, the risk of revision

Table 1 Characteristic of included studies

References	Years	Mean age	Female	Follow-up (years)	BMI	Unilateral or bilateral	Preoperative ROM	Prosthesis		Outcome
								UKA	TKA	
Newman [20]	1998	69.7	55	5	–	Unilateral	101.5	St Georg Sled; Waldemar Link, Hamburg, Germany	Kinematic; Howmedica, Rutherford, New Jersy	BKS, complications, revision
Weale [25]	1999	–	–	5	–	Unilateral	101.5	St Georg Sled; Waldemar Link, Hamburg, Germany	Kinematic; Howmedica, Rutherford, New Jersy	VAS, ROM
Costa [5]	2011	73	44	5	–	Bilateral	–	Stryker Orthopaedics	Stryker Orthopaedics	VAS, KSS, complications, revision
Sun [23]	2012	60.5	66	4	30	Bilateral	–	Oxford Biomet, Warsaw, IN, USA	AGC, Biomet	KSS, ROM, complications, revision

VAS visual analog score, *ROM* range of motion, *KSS* knee society score, *BKS* Bristol knee score

Table 2 Risk of bias assessment

References	Sequence generation	Allocation concealment	Blinding	Incomplete outcome data	Selective outcome report	Free of other bias	Description of other bias
Newman [20]	Y	N	N	N	Y	N	Per-protocol analysis
Weale [25]	Y	N	N	N	Y	N	Per-protocol analysis
Costa [5]	U	N	N	N	Y	N	Post randomization exclusion per-protocol analysis
Sun [23]	Y	Y	N	Y	Y	Y	–

surgery was higher in the UKA group (Chi-square = 2.13, $df = 2$, $p = 0.345$, $I^2 = 6$ %, Fig. 3) with a pooled RR of 5.36 (95 % CI 1.06, 27.08) when compared to the TKA group, indicating that the chance of requiring revision surgery was approximately 5.4 times higher in the UKA group when compared to the TKA group.

Neither contour funnel nor Egger's test suggested evidence of publication bias.

Discussion

In the UK and North America, UKA has increased in popularity in recent years. Many authors have shown good long-term survivorship following UKA as well as better kinematics and function. However, some surgeons still regard UKA as a temporary procedure and believe that patients over 60 years of age are best treated with a TKA. Randomized controlled trials represent the best study design to compare UKA with TKA. However, no consistent results have been shown in these published randomized trials. The use of both UKA and TKA have been increasing worldwide.

This review suggests that UKA has no significant difference in outcomes for knee scores, function scores and ROM than total knee arthroplasty. Patients who underwent UKA were approximately five times more likely to undergo revision surgery than patients who underwent TKA. On the other hand, patients who underwent UKA were approximately 60 % less likely to have early postoperative complications after surgery than patients who underwent TKA.

Previous meta-analysis [28] has shown that UKA has a better postoperative ROM with improved pain relief and function compared to TKA, but in terms of knee function did not show a statistically significant difference. Postoperative complications in the TKA group were higher when compared to the UKA group, whereas revision rates were higher in the UKA group when compared to the TKA group. Only one study was a RCT with a total of 102 subjects, and six studies were cohort studies. This review included three more RCTs with a total of 226 subjects. There was no difference in postoperative function, pain and ROM in the knee between the two groups.

This study has several strengths. First of all, this study included 4 RCTs in the pooling of relevant clinical

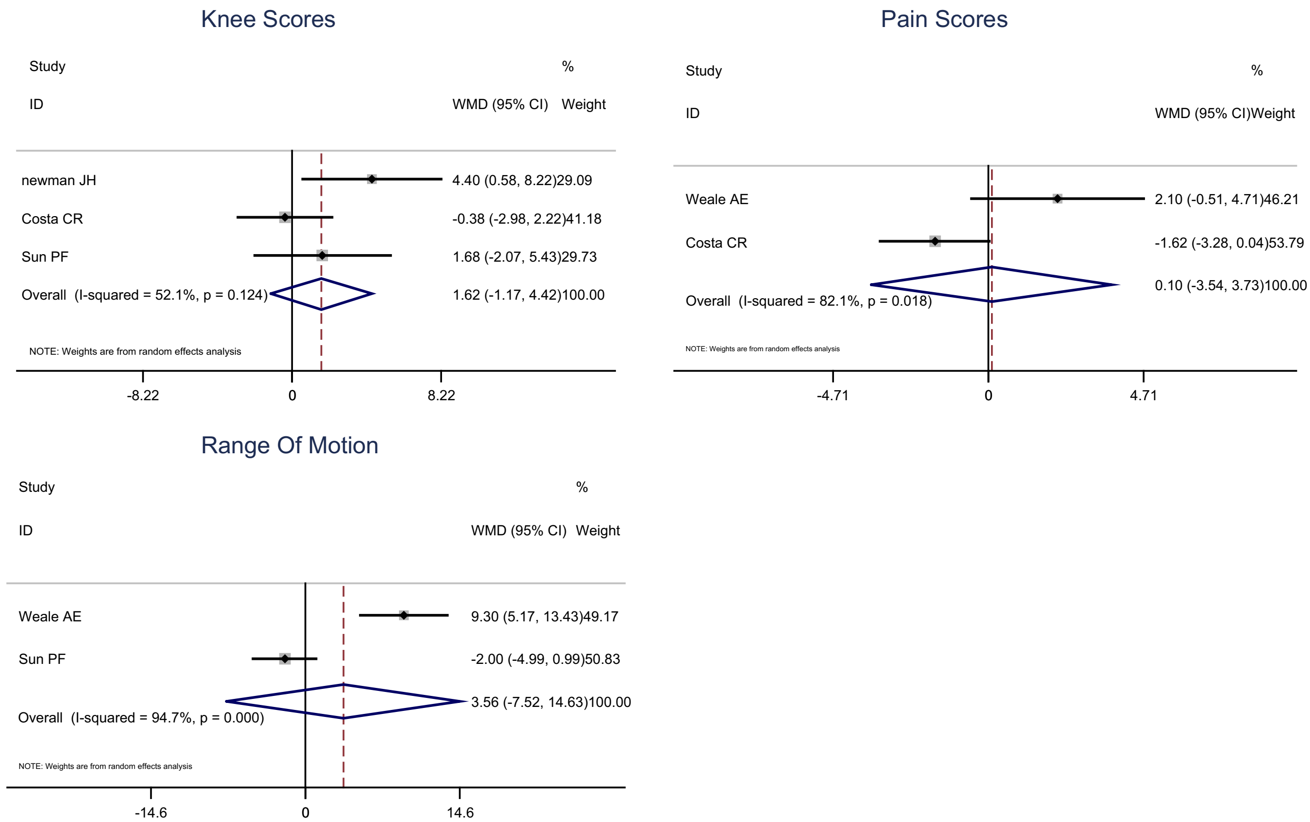

Fig. 2 Forest plot of continuous outcomes between UKA and TKA

Table 3 Mean differences between UKA and TKA

References	UKA			TKA		
	N	Mean	SD	*N*	Mean	SD
(A) KSS						
Newman [20]	50	91.1	9.63	52	86.7	10.07
Costa [5]	34	91.59	5.46	34	91.97	5.46
Sun [23]	28	80.58	9.03	28	78.9	4.56
UMD (95 % CI)		1.62 (95 % CI −1.17, 4.42)				
(B) VAS						
Weale [25]	50	37.5	4.7	52	35.4	8.3
Costa [5]	34	3.9	3.49	34	5.52	3.49
UMD (95 % CI)		0.10 (95 % CI −3.54, 3.73)				
(C) ROM						
Weale [25]	50	117.3	9.4	52	108	11.8
Sun [23]	28	115	4	28		1177
UMD (95 % CI)		1.88 (95 % CI −0.54, 4.30)				

UMD unstandardized mean difference

Table 4 Comparisons of dichotomous outcomes between UKA and TKA

References	UKA		TKA		OR	95 % CI
	Yes	No	Yes	No		
(A) Complications						
Newman [20]	2	48	5	47	0.39	(0.07, 2.12)
Costa [5]	0	34	2	32	0.19	(0.01, 4.08)
Sun [23]	3	25	7	21	0.33	(0.08, 1.57)
Pooled RR					0.34	0.12, 0.96
(B) Revision						
Newman [20]	1	49	1	51	1.04	0.07, 16.18
Costa [5]	5	29	0	34	11.00	0.63, 191.48
Sun [23]	7	21	0	28	15.00	0.90, 250.66
Pooled OR					5.36	1.06, 3.08

outcomes (i.e., postoperative functional scores, pain score, range of motion, early postoperative complications and revision rates) of UKA and TKA. Secondly, possible causes of heterogeneity were explored if covariate data at baseline (e.g., mean age, percent female, follow-up times, unilateral or bilateral TKA) were available. However, due to the small number of studies a sensitivity analysis could not be done. Publication bias for each outcome was also assessed. However, due to the small number of studies selected for this meta-analysis a funnel plot was not drafted to display publication bias.

There are some limitations in this study. This study did not pool a social outcome such as quality of life due to the

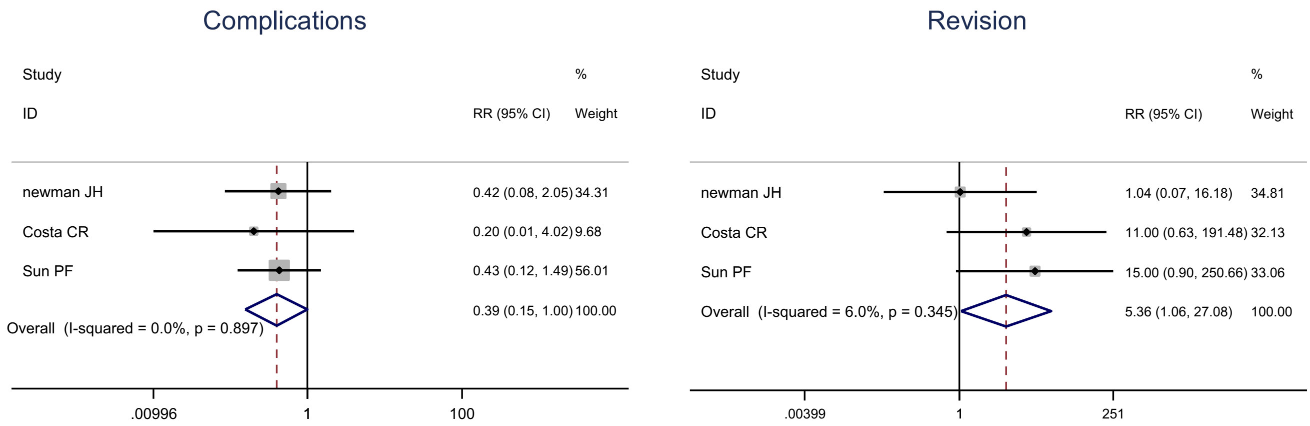

Fig. 3 Forest plot of dichotomous outcomes between UKA and TKA

Table 5 Evidence profile for UKA and TKA

Outcome	No. of studies	No. of subjects	I^2 (%)	Pooled effects	Evidence profile	Quality of evidence
KSS	3	112 versus 114	52.1	1.62 (−1.17, 4.42)	Few methodological limitation (i.e., did not describe method of randomizations, allocation concealment, blinding Quite imprecise estimated effects with no clinical impacts Moderate heterogeneity and no publication bias	2B[a]
VAS	2	84 versus 86	82.1	0.1 (−3.54, 3.73)	Few methodological limitation (i.e., did not describe method of randomizations, allocation concealment, blinding) Quite imprecise estimated effects with no clinical impacts High heterogeneity and no publication bias	2B
ROM	2	78 versus 80	94.7	3.56 (−7.52, 14.63)	Few methodological limitation (i.e., did not describe method of randomizations, allocation concealment, blinding) Quite imprecise estimated effects with no clinical impacts High heterogeneity and without publication bias	2B
Complications	3	112 versus 114	0	0.39 (0.16, 1.00)	Few methodological limitation (i.e., did not describe method of randomizations, allocation concealment, blinding) No heterogeneity and without publication bias	2B
Revision	3	112 versus 114	6	5.36 (1.06, 27.08)	Few methodological limitation (i.e., did not describe method of randomizations, allocation concealment, blinding) No evidence of heterogeneity and publication bias	2B

2B = Intermediate-strength recommendation, may be applicable to some patients depending on circumstances or society

[a] May be able to upgrade due to strength of effects and if no present of publication

fact that there was insufficient data. All studies had a mean follow-up time of about 4–5 years, and thus, long-term effects of UKA and TKA are still in question.

The quality of evidence was also assessed for each outcome following suggestion (Guyatt et al. 2008) [10] (Table 5). The quality of evidence was intermediate strength for all outcomes.

Conclusion

In short-term outcomes (5 years or less, with follow-up of 0–5 years), TKA had higher early postoperative complications than UKA, but had lower surgical revision rates. There was only one study that reported long-term survivorship (more than 5 years, with follow-up of 5–15 years). Further research that assesses long-term survivorship is necessary to further evaluate UKA and TKA in the treatment of unicompartmental knee OA.

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Conflict of interest All authors declare that they have no conflict of interest.

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