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SYSTEMATIC REVIEW

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Functional outcome and cost effectiveness of patellar resurfacing and non-resurfacing in total knee arthroplasty: systematic review and meta-analysis

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Abstract

Background Total knee arthroplasty (TKA) is rising globally, with patellar management impacting outcomes. Resurfacing reduces pain and revision rates but poses complications, while non-resurfacing lowers costs but risks persistent pain. This study updates previous meta-analyses by comparing the functional and economic outcomes of both approaches.

Methods This systematic review and meta-analysis followed PRISMA guidelines. Studies comparing patellar resurfacing and non-resurfacing in TKA with functional outcomes in adults were included. Five databases were searched until February 6, 2024. Two authors independently extracted data and assessed risk of bias. Any disagreements were resolved by a third author. Statistical analysis used a random-effects model, reporting mean differences (MD) and odds ratios (OR) with 95% CI. Sensitivity and subgroup analyses were performed to assess heterogeneity and reliability.

Results A total of 49 studies (34 RCTs, 15 observational) were included from 963 screened records. Analysis of 22 studies found no significant difference in Knee Society Score (KSS) function between resurfacing and non-resurfacing (MD 2.03; 95% CI 0.58–3.48; $p = 0.59$, $I^2 = 53\%$). Resurfacing significantly reduced anterior knee pain (OR 0.61; 95% CI 0.42–0.87; $p = 0.007$, $I^2 = 70\%$). However, no significant differences were observed in pain scale, range of motion (ROM), or Oxford Knee Score. Three studies assessed economic outcomes using Incremental Net Benefit (INB) and Incremental Cost-Effectiveness Ratio (ICER) showed no significant cost-effectiveness.

Conclusions Patellar resurfacing in TKA significantly reduces anterior knee pain but shows no advantage in KSS function, pain scale, Oxford Knee Score, ROM, or cost-effectiveness. Surgical decisions should be individualized to optimize patient outcomes.

Keywords Total knee arthroplasty, Patellar resurfacing, Knee surgery

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Background

Total knee arthroplasty (TKA) is commonly used to treat end-stage knee disease. Osteoarthritis (OA) is the primary cause of TKA, followed by rheumatoid arthritis (RA), other inflammatory arthritis, trauma, malignancy, or dysplasia [1]. The number of TKA procedures is increasing globally and is projected to rise by 85% in 2030 [2]. TKA has demonstrated remarkable improvement and high patient satisfaction, with satisfaction rates ranging from 80–95% [3]. Surgical techniques in TKA, such as patellar management, play a crucial role in patient outcomes. Choosing between patellar resurfacing and non-resurfacing affects pain relief, joint function, and the risk of future revision surgery [4, 5].

Advocates of resurfacing argue it can significantly reduce anterior knee pain and the need for secondary procedures. However, concerns remain about potential complications such as patellar fracture, loosening, instability, and increased surgical time [4, 5]. On the other hand, non-resurfacing preserves bone and may reduce operative time and costs, but it has been associated with persistent anterior knee pain and a greater likelihood of requiring revision surgery [6–14].

Previous studies have demonstrated favorable outcomes associated with patellar resurfacing, particularly in reducing anterior knee pain and improving postoperative function [15]. However, the procedure remains controversial due to risks such as infection, joint stiffness, and mechanical complications, which can result in extended recovery periods and higher cumulative treatment costs [4, 16]. In Indonesia, where projections estimate up to 19.5 million cases of joint disease by 2030, patellar resurfacing is not yet widely practiced [17, 18]. However, no studies have been conducted in Indonesia to assess the effectiveness of patellar resurfacing in total knee arthroplasty. This lack of national data limits the ability to assess its value in a setting where healthcare costs and accessibility are significant concerns.

Moreover, the most recent meta-analysis by Chen et al. (2021) included studies only up to May 2020. [19] Our study builds on this foundation by incorporating more recent evidence published between 2020 and 2024, thereby addressing both the clinical and economic dimensions of this ongoing debate.

Therefore, the aim of this study is to systematically compare the functional outcomes of patellar resurfacing versus non-resurfacing in TKA using validated measures such as the Knee Society Score (KSS) function, Knee Injury and Osteoarthritis Outcome Score (KOOS), anterior knee pain incidence, pain scales (e.g., Visual Analog Scale [VAS], Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC]), Oxford Knee Score, and postoperative range of motion (ROM). Functional outcomes in this study are defined as clinical and patient-reported metrics that assess pain, mobility, and knee function following TKA. Furthermore, this review evaluates the economic implications of both surgical approaches by analyzing the mean cost of operation, incremental cost, quality-adjusted life years (QALYs), and their incremental comparisons as expressed through incremental net benefit (INB) and incremental cost-effectiveness ratio (ICER).

Methods

Eligibility criteria

This systematic review and meta-analysis were conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [20]. We included studies with the following criteria: 1) studies evaluating total knee arthroplasty (TKA), 2) studies comparing head-to-head patellar preservation (non-resurfacing) and resurfacing with and without other interventions in TKA, 3) functional outcomes presented in statistical difference, and 4) studies with adult population (> 18 years old). Functional outcomes included anterior knee pain, range of motion, and scores reported by patients. We included studies in any language and translated them into English for data extraction. We excluded case reports, case series, and non-randomized studies of interventions (NRSIs) with experimental designs due to their higher risk of bias and lack of comparability.

Search strategy

Literature search was conducted in five databases: PubMed, Scopus, Cochrane, ProQuest, and EBSCOhost until 6 February 2024. Keywords included "total knee arthroplasty," "patellar resurfacing," "patellar preservation," and "functional outcomes." Full search terms and the PICO framework are shown in Appendix 1 and 2.

Data extraction

Two authors independently extracted data from each study. Any disagreements were resolved through discussion with a third author. Data extraction was done using Microsoft Excel, and duplicate entries were manually removed. Data extracted from full-text articles included author, year of publication, country, study design, sample size, number of knees, age, gender proportion, disease etiology, implant used, follow-up duration, and outcomes of interest. Outcomes of interest were functional outcomes of the patients, which included Knee Society Score (KSS) function, Knee Injury and Osteoarthritis Outcome Score (KOOS), presence of anterior knee pain, pain scale (e.g., Visual Analog Scale [VAS], Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC]), Oxford Knee Score, postoperative range of motion (ROM).

Functional outcomes of interest included the Knee Society Score (KSS) function, KOOS, presence of anterior knee pain, pain scales (e.g., VAS and WOMAC), Oxford Knee Score, and postoperative range of motion (ROM). In addition, data related to the economic impact of patellar resurfacing were extracted where available. These included direct costs of surgery, incremental cost differences, quality-adjusted life years (QALYs), and comparative economic measures such as the Incremental Cost-Effectiveness Ratio (ICER) and Incremental Net Benefit (INB). This allowed for a comprehensive comparison of both functional and cost-effectiveness outcomes between the two surgical approaches.

Risk of bias assessment

Two authors independently assessed the risk of bias in included studies. Any discrepancies were decided by the third author. In randomized-controlled trials (RCT) studies, The Cochrane Risk-of-Bias tool was used to assess the methodological quality of included studies which consists of following domains: random sequence allocation, allocation concealment, blinding of participants & personnel, blinding of outcome assessment, incomplete outcome, selective reporting, and other bias. Studies were classified as having 'low', 'high', or 'unclear' risk of bias. Newcastle–Ottawa Scale (NOS) was used in observational studies with the following domain: selection, comparability, and outcome. Study will be judged with "good", "fair", or "poor" quality. Funnel plot for reporting bias was used if there were more than ten studies included. Although non-randomized studies were included, the ROBINS-I tool was not applied due to the registry-based nature of the data, which lacked the detailed intervention-level variables needed for ROBINS-I assessment.

Statistical analysis

Data were presented in tables and figures. Data syntheses were performed using Review Manager 5.4 (Cochrane Collaboration, Oxford, England) software. Any article that did not include specific outcomes were not included in synthesis. A p-value < 0.05 was considered statistically significant. However, in line with current best practices, 95% confidence intervals (CIs) were emphasized as the primary indicators of statistical significance to reduce overreliance on p-value thresholds. We judged as there were diverse interventions and settings (e.g., implant used and TKA approach between surgeons), there would be heterogeneity between studies, which led to the use of random-effect meta-analysis model. In continuous variable, we planned to calculate mean difference (MD) with 95% CI. In dichotomous variable, we planned to calculate odds ratio (OR) with 95% CI. Sensitivity analysis was performed by excluding one study at the time and repeating the analysis to assess the reliability of outcomes among included studies in the syntheses. Heterogeneity between studies was assessed using *chi-square* test with I^2 statistics. In studies with substantial heterogeneity, subgroup analysis was performed.

Results

Study characteristics

A total of 963 potential studies were identified in the initial search. After deduplication, a total of 444 records were screened with title and abstract. Of these, 31 records were sought for retrieval with only a total of 22 full-text articles were obtained. 7 articles were excluded due to absence of comparison between resurfacing and non-resurfacing in TKA. Combined with articles included in the previous review, a total of 49 articles were included in this study, which consisted of 34 RCTs and 15 observational studies. Study selection can be seen in Fig. 1.

The risk of bias of included studies in RCT and observational studies can be seen in Fig. 2 and Table 1 respectively. High-risk bias was seen in the domain of allocation concealment (2 studies [21, 22]), blinding of participants and personnel (3 studies [21, 23, 24]), incomplete outcome (1 study [25]), and selective reporting (1 study [26]). In observational studies, all studies were judged as good quality except for Maradit et al. with fair quality due to bias in domain of comparability. Study characteristics and the detailed outcomes can be seen in Tables 2, 3, 4.

KSS function

A total of 22 studies were included in the analysis of Knee Society Score (KSS) function, representing patient-reported outcomes comparing patellar resurfacing and non-resurfacing [21, 24, 28, 30, 32, 33, 36–38, 40, 41, 43, 44, 46, 48, 49, 51, 54, 56, 62]. Pooled analysis of mean difference in KSS were not significant between patellar resurfacing and non-resurfacing. We observed substantial variability between studies ($I^2 = 89\%$). (Fig. 3) Sensitivity analysis was performed by excluding one study at the time, which showed that exclusion of Smith et al. resulted in significantly better KSS function in patellar resurfacing group (MD 2.03; 95% CI 0.58–3.48; $p = 0.006$ with $I^2 = 53\%$).

Subgroup analyses were performed based on the country of origin of each study. Significant difference in mean was observed in Asian population, which was in favor to patellar resurfacing in TKA ($p < 0.00001$, $I^2 = 0\%$). (Fig. 4) Funnel plot for reporting bias in KSS function outcome can be seen in Fig. 5.

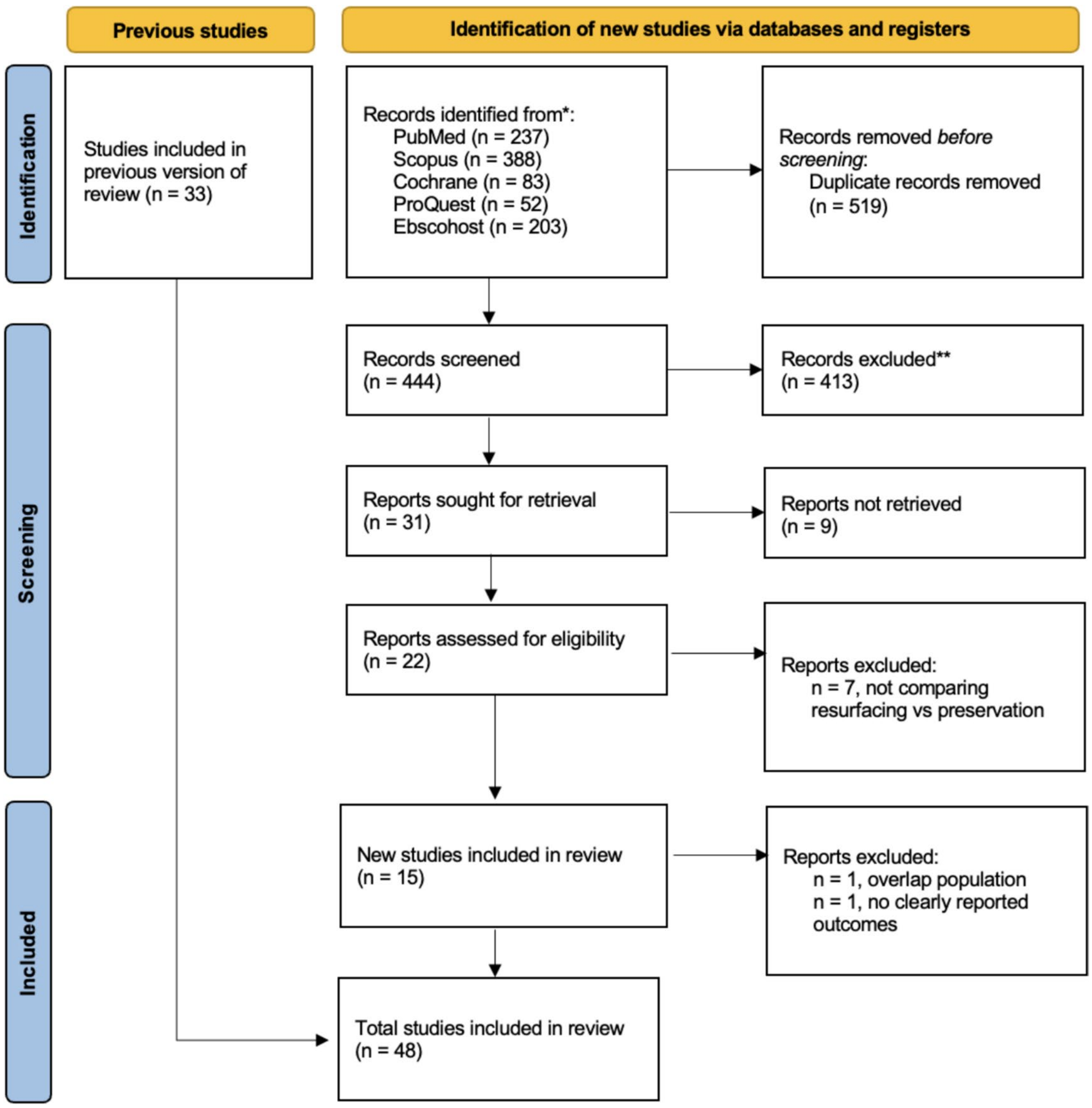

Fig. 1 PRISMA Flow chart of searching strategy

Anterior knee pain

We included a total of 22 studies [21, 22, 25, 30–35, 37, 38, 40, 43, 47–49, 52, 55–58, 69] which included anterior knee pain outcomes between patellar resurfacing and non-resurfacing in TKA. Pooled analysis showed significant difference in odds ratio (OR) of 0.61 (95% CI 0.42–0.87; $p = 0.007$) between patellar resurfacing and non-resurfacing. Substantial heterogeneity was observed between studies ($I^2 = 70\%$). (Fig. 6) Sensitivity analysis showed no change in combined estimates with removal of any one study.

Subgroup analysis was performed based on country origin between studies. Significant difference was seen in European population, which was in favor to patellar resurfacing in TKA despite heterogeneity still substantial (OR 0.30; 95% CI 0.13–0.69; $p = 0.004$, $I^2 = 68\%$) (Fig. 7). The funnel plot assessing reporting bias in the anterior knee pain outcome is shown in Fig. 8.

Pain scale

We included a total of 6 studies [24, 36, 39, 44–46] which included pain scale (including VAS and WOMAC) in the knee between patellar resurfacing and non-resurfacing in TKA. Pooled analysis showed that mean difference was not significant between patellar resurfacing and non-resurfacing. No heterogeneity was observed between studies ($I^2 = 0\%$). (Fig. 9) Sensitivity analysis showed no

Fig. 2 Risk of bias in RCT studies

Table 1 Risk of bias in observational studies

No	Study	Year	Risk of bias assessment			Total	Interpretation
			Selection (max 4)	Comparability (max 2)	Outcome (max 3)		
1	Misra	2003	4	0	3	7	Good
2	Garneti	2008	4	2	2	8	Good
3	Park	2010	4	1	3	8	Good
4	Maradit	2017	4	0	1	5	Fair
5	Weeks	2018	4	1	3	8	Good
6	Maney	2019	3	2	2	7	Good
7	Butnaru	2020	4	1	2	7	Good
8	Thilak	2020	4	2	2	8	Good
9	Huish	2020	4	2	2	8	Good
10	Ko	2022	4	2	2	8	Good
11	Noh	2022	4	2	3	9	Good
12	Abbot	2023	4	2	3	9	Good
13	Samih	2023	4	2	2	8	Good
14	Robben	2023	4	2	3	9	Good

change in combined estimates with removal of any one study.

ROM angle

We included a total of 7 studies [21, 33, 38, 41, 43, 52] which included ROM angle in the knee between patellar resurfacing and non-resurfacing in TKA. Pooled analysis showed that mean difference was not significant between patellar resurfacing and non-resurfacing. No heterogeneity was observed between studies ($I^2 = 0\%$). (Fig. 10) Sensitivity analysis showed no change in combined estimates with removal of any one study.

Oxford knee score

We included a total of 9 studies [26, 41, 42, 44, 46, 52, 66, 67] which included Oxford Knee Score in the knee between patellar resurfacing and non-resurfacing in TKA. Pooled analysis showed that mean difference was not significant between patellar resurfacing and non-resurfacing. Moderate heterogeneity was observed between studies ($I^2 = 44\%$). (Fig. 11) Sensitivity analysis showed no change in combined estimates with removal of any one study.

Incremental Net Benefit (INB)

We included a total of 3 studies [26, 42, 59] that provided outcomes on mean cost, quality-adjusted life-years (QALYs), and their incremental comparisons between resurfacing and non-resurfacing in TKA. As shown in Table 4, we also report additional data on the incremental cost-effectiveness ratio (ICER) and incremental net benefit (INB) as reported by each of the studies included. A pooled analysis was conducted using the INB values obtained from each study, with a value of 30,000 Great British Pound Sterling (GBP) per QALY for one year of life. The pooled analysis of Incremental Net Benefit (INB) revealed no statistically significant difference between resurfacing and non-resurfacing approaches, indicating comparable cost-effectiveness profiles under a £30,000/QALY threshold. Sensitivity analysis showed no change in combined estimates with removal of any one study. (Fig. 12) Funnel plot for reporting bias in pooling INB can be seen in Fig. 13.

Discussion

This review aims to compare the functional outcome between patellar resurfacing and non-resurfacing in TKA. In present meta-analysis, we found significantly lower anterior knee pain in patients receiving patellar resurfacing compared to non-resurfacing (including in European subgroup). Significantly better KSS function was also seen in patellar resurfacing in Asian subgroup. However, no significant difference in pain scale using VAS or WOMAC score, ROM angle, and Oxford Knee Score between resurfacing and non-resurfacing group.

These findings reinforce the core debate surrounding patellar resurfacing: while clinical benefits in anterior knee pain are evident, functional and patient-reported metrics present a more nuanced picture. Patellar resurfacing has been widely used as routine adjunct in TKA procedure. It is performed by removal of undersurface of patella followed by insertion of plastic surface or polyethylene implant [5, 70]. The effect of patellar resurfacing to anterior knee pain has been reported by previous studies.

Table 2 Study characteristics

No	Author	Year	Location	Design	Subjects'characteristic (total; R vs NR)					Study characteristics	
					Number (patients)	Number (knees)	Age	Sex (%male)	Etiology	Implant	Follow-up (months)
RCT											
1	Partio [22]	1995	Finland	RCT	95	NI	67.5	22	OA/RA	Johnson & Johnson Press-fit condylar implant	36
2	Feller [27]	1996	Australia	RCT	38	38; 19 vs 19	70.8	55.3	OA	Howmedica PCA Modular prosthesis	36
3	Kajino [23]	1997	Japan	RCT	52	52; 26 vs 26	56.1	7.7	RA	Yoshino-Shoji total knee prosthesis; Biomet, Warsaw, Indiana	79.2
4	Schroeder-Boersch [28]	1998	Germany	RCT	40	40; 20 vs 20	72.6; 73 vs 72.2	30	OA	Howmedica Duracon	24
5	Newman [29]	2000	UK	RCT	84	84; 42 vs 42	71.9; 72 vs 71.1	32.8	OA	Howmedica PCA Modular prosthesis	60
6	Barrack [25]	2001	USA	RCT	93	93; 47 vs 46	66.2	NI	OA	NI	60
7	Wood [30]	2002	Australia	RCT	200	200; 92 vs 128	73.7; 73.7 vs 73.7	52.7	NIA	Zimmer Miller-Galante II	48
8	Mayman [31]	2003	Canada	RCT	100	100; 50 vs 50	70; 72 vs 68	42	OA	Anatomic Medullary Knee, DePuy, Warsaw, IN	120
9	Waters [32]	2003	UK	RCT	390	474; 243 vs 231	69.1	40.2	OA/IA	Johnson & Johnson Press-fit condylar implant	63.6
10	Burnett [33]	2004	Canada	RCT	83	90: 42 vs 48	70; 71 vs 69	43.3	OA	DePuy Anatomic Medullary Knee	120
11	Gildone [34]	2005	Italy	RCT	56	56; 28 vs 28	74.1; 73.6 vs 74.6	30.4	OA	Zimmer Nexgen	25.2
12	Campbell [35]	2006	Australia	RCT	100	100; 46 vs 54	72.1; 71 vs 73	28	OA	Zimmer Miller-Galante II	120
13	Myles [36]	2006	UK	RCT	50	50; 25 vs 25	70	52	NIA	DePuy LCS rotating platform	21.6
14	Smith [37]	2008	Australia	RCT	164	159; 73 vs 86	71.5; 71.9 vs 71.2	50.4	OA	Smith & Nephew PROFIX	48
15	Burnett [38]	2009	USA	RCT	86	118; 58 vs 60	66.2; 65.3 vs 67.1	79.1	OA	Zimmer Miller-Galante II	120
16	Breeman [26]	2011	UK	RCT	1715	1715; 861 vs 854	70 vs 70	44.5	OA	NI	60

Table 2 (continued)

No	Author	Year	Location	Design	Subjects'characteristic (total; R vs NR)					Study characteristics	
					Number (patients)	Number (knees)	Age	Sex (%male)	Etiology	Implant	Follow-up (months)
17	Beaupre [39]	2012	Canada	RCT	38	38; 21 vs 17	63.6; 64.9 vs 62	31.6	NIA	Profix™ Total Knee System	120
18	Liu [40]	2012	China	RCT	144	132; 68 vs 64	67.7; 67.5 vs 68	62.9	OA	Press Fit Condylar, DePuy, Warsaw, IN	84
19	Ferguson [41]	2014	UK	RCT	176	176; 88 vs 88	69.8	47	OA	PFC Sigma© Posterior Stabilised, DePuy, Warsaw, IN	48
	Ferguson(b) [41]	2014	UK	RCT	176	176; 89 vs 87	70.2	47	OA	PFC Sigma© Posterior Stabilised, DePuy, Warsaw, IN	48
20	Murray [42]	2014	UK	RCT	1715	1617; 816 vs 798	70; 70 vs 70	44.3	OA/RA	NI	120
21	Roberts [43]	2015	USA	RCT	114	350; 178 vs 172	70.7; 70.2 vs 71.3	48.6	OA	DePuy Sigma CR	124.8
22	Aunan [44]	2016	Norway	RCT	129	129; 63 vs 66	69.5; 70 vs 69	43.4	OA	Zimmer Nexgen	36
23	Ali [45]	2016	Sweden	RCT	74	69; 33 vs 36	68.5; 68 vs 69	39.2	OA	Triathlon CR	72
24	Vukadin [46]	2017	Serbia	RCT	60	59; 30 vs 29	67.4; 68.1 vs 66	45	OA	Zimmer Nexgen LPS-type	24
25	Dong [47]	2018	China	RCT	106	96; 48 vs 48	67.7	43	OA	Posterior cruciate stabilizing total knee prostheses	36
26	Jia [48]	2018	China	RCT	30	60; 30 vs 30	57.2	80	OA	NI	31.2
27	Kaseb [24]	2018	Iran	RCT	50	50; 24 vs 26	64.8	16	NIA	Profix™ Total Knee System	6
28	Ha [49]	2019	China	RCT	120	120; 60 vs 60	65.2	63.3	OA	Stryker Scorpio NRG	60
29	Chawla [50]	2019	India	RCT	100	100; 50 vs 50	NI	20	OA	NI	60
30	Kaseb [51]	2019	Iran	RCT	73	73; 29 vs 44	66.7; 68.1 vs 65.75	20.5	OA	Zimmer Nexgen	8.68
31	Thiengwit-tayaporn [52]	2019	Thailand	RCT	84	80; 41 vs 39	68.2; 68.2 vs 68.2	17.5	OA	Smith & Nephew Legion PS Total Knee System	12
32	Koh [53]	2019	Korea	RCT	98	98; 49 vs 49	70	NI	OA	NI	24
33	van Raaij [54]	2021	Netherland	RCT	40	42; 21 vs 21	69.5	38.1	OA	AGC Total Knee System, Biomet, Warsaw, IN	24

Table 2 (continued)

No	Author	Year	Location	Design	Subjects'characteristic (total; R vs NR)					Study characteristics	
					Number (patients)	Number (knees)	Age	Sex (%male)	Etiology	Implant	Follow-up (months)
34	Deroche [21]	2022	France	RCT	245	250; 125 vs 125	69.3; 68.8 vs 69.7	58.1	OA	Anatomic, AMPLITUDE®, Valence 26,000, FRANCE	18
Observational											
1	Misra [55]	2003	UK	Observational	103	105; 48 vs 57	67.5; 67.4 vs 67.6	37.1	OA/RA	PFC Sigma	57
2	Garneti [56]	2008	UK	Observational	121	142; 76 vs 66	NI; 71 vs 74	NI	OA	Scorpio	NI; 18 vs 33
3	Park [57]	2010	Korea	Observational	44	61; 36 vs 25	64.3; 64.7 vs 63.6	7.02	OA	LCS, DePuy, Warsaw, IN, USA	NI; 149 vs 140.7
4	Maradit [58]	2017	USA	Observational	15,497	21,371; 20,969 vs 402	NI; 68.7 vs 61.9	44.06	Degenerative Arthritis, Inflammatory Arthritis, Avascular Necrosis	PFC, Nexgen legacy, Sigma, PCA, Genesis, Custom Designs, Others	91.2
5	Weeks [59]	2018	Canada	Observational	443,948	443,948; 218,033 vs 225,915	NI	NI	OA	NI	168
6	Maney [60]	2019	New Zealand	Observational	57,766	57,766; 21,087 vs 32,148 vs 4531	68; 68.52 vs 67.67 vs 68.57	49.11	OA	NexGen (Zimmer), the Triathlon (Stryker), the LCS Knee System (DePuy Synthes), and the Genesis II (Smith & Nephew)	> 24
67	Butnaru [61]	2020	France	Observational	83	100	68	36	OA	Third Condyle (HLS KneeTec, Tornier-Corin, France)	32.4
8	Thilak [62]	2020	India	Observational	63	103; 62 vs 41	77.8; 77.2 vs 78.5	17.4	OA	Sigma PFC, Nexgen	140; 137 vs 144
9	Huish [63]	2020	USA	Observational	84	NI	66.5	30.95	OA	U2 Knee	51; 48 vs 57

Table 2 (continued)

No	Author	Year	Location	Design	Subjects'characteristic (total; R vs NR)					Study characteristics	
					Number (patients)	Number (knees)	Age	Sex (%male)	Etiology	Implant	Follow-up (months)
10	Ko [64]	2022	Korea	Observational	43	80; 40 vs 40	NI; 64.42 vs 64.35	2.3	OA/RA	Zimmer NexGen; Scorpio (Stryker, Mahwah, NJ, USA), Vanguard (Biomet, Warsaw, IN, USA), Sigma PFC (DePuy Orthopedics, Warsaw, IN, USA), ATTUNE knee system (DePuy Orthopedics, Warsaw, IN, USA), and Genesis II (Smith and Nephew, Memphis, TN, USA)	NI; 68.16 vs 71.04
11	Noh [65]	2022	Korea	Observational	500	NI	74.9	10.8	OA	Vanguard, Attune, PFC Sigma, Nexgen, Persona	36.6
12	Abbot [66]	2023	UK	Observational	3122	3122; 1453 vs 1669	NI; 71.6 vs 71.4	38.2	OA/RA	Posterior stabilizing; cruciate retaining	24
13	Samih [4]	2023	Marroco	Observational	100	106; 29 vs 77	65	17	OA	Semi-constrained posterior stabilized	18
14	Robben [67]	2023	Netherland	Observational	NI	17,224; 4525 vs 12,699	NI; 67.7 vs 68.5	39.3	OA	Genesis II, NexGen, Sigma PFC, Vanguard	12
15	Gerow [68]	2024	USA	Observational	950	NI	62	42	OA, RA, Osteonecrosis	Vanguard Total Knee System (Zimmer-Biomet, Warsaw, Indiana)	12

Table 3 Study outcomes

No	Author	Year	KSS function	KOOS	Anterior knee pain	Knee pain scale	Oxford knee score	ROM	Other outcomes	
RCT										
1	Partio [22]	1995	-	-	0.09 [0.01–0.69]	-	-	-	NA	-
2	Feller [27]	1996	-	-	-	-	-	-	Patellar score HSS Knee	−2.2 [−4.98; 0.58] −2.9 [−6.82; 1.02]
3	Kajino [23]	1997	-	-	-	-	-	-	HSS Knee	-
4	Schroeder-Boersch [28]	1998	16.9 [4.53; 29.27]	-	-	-	-	-	NA	-
5	Newman [29]	2000	-	-	0.08 (0.00; 1.32)	-	-	-	NA	-
6	Barrack [25]	2001	-	-	1.1 [0.47; 2.61]	-	-	NS	NA	-
7	Wood [30]	2002	5.00 (3.62; 6.38)	-	0.54 (0.31; 0.91)	-	-	-	NA	-
8	Mayman [31]	2003	-	-	0.12 [0.04; 0.35]	-	-	-	NA	-
9	Waters [32]	2003	2.60 (−2.26; 7.46)	-	0.21 (0.12; 0.38)	-	-	-	NA	-
10	Burnett [33]	2004	−0.80 (−11.83; 10.23)	-	1.60 (0.55; 4.67)	1.6 [−1.97; 5.17]	-	−0.1 [−6.43; 6.23]	NA	-
11	Gildone [34]	2005	-	-	0.08 (0.01; 1.30)	-	-	-	NA	-
12	Campbell [35]	2006	-	-	1.09 (0.61; 1.93)	-	-	-	NA	-
13	Myles [36]	2006	−15.60 (−25.55; −5.65)	-	-	VAS: −4.3 [−15.72; 7.12] WOMAC: −0.9 [−2.45; 0.65]	-	-	WOMAC stiffness WOMAC function	−0.3 [−1.19; 0.59] 1.8 [−3.17; 6.77]
14	Smith [37]	2008	−10.00 (−11.99; −8.01)	-	1.44 (0.84; 2.47)	0 [−1.64; 1.64]	-	-	NA	-
15	Burnett [38]	2009	−6.00 (−17.10; 5.10)	-	0.97 (0.67; 1.39)	-	-	−3 [−8.17; 2.17]	NA	-
16	Breeman [26]	2011	-	-	-	-	0.44 [−0.69; 1.57]	-	Mean cost QALY	£7577 vs £7726 6.01 vs 5.37
17	Beaupre [39]	2012	-	-	-	32.9 ± 18.2 vs 34.3 ± 21.5; NS	-	-	WOMAC stiffness WOMAC function	24.4 ± 24.5 vs 8.3 ± 32.3; NS 24.1 ± 16.6 vs 19.5 ± 16.9
18	Liu [40]	2012	−3.60 (−2.29; 9.49)	-	1.18 (0.50; 22.79)	0.7 [−2.04; 3.44]	-	-	NA	-
19	Ferguson [41]	2014	4.00 (−2.81; 10.81)	-	-	-	2.3 [−1.02; 6.82]	0.9 [−3.93; 5.73]	NA	-
	Ferguson(b) [41]	2014	2.20 (−3.88; 8.28)	-	-	-	4.2 [1.26; 7.14]	−3.2 [−7.37; 0.97]	NA	-
20	Murray [42]	2014	-	-	-	-	0.1 [−1.43; 1.83]	-	Mean cost QALY	−£104 (−£630 to £423; p = 0.70) 0.187 (−0.025 to 0.399; p = 0.08)

Table 3 (continued)

No	Author	Year	KSS function	KOOS	Anterior knee pain	Knee pain scale	Oxford knee score	ROM	Other outcomes	
21	Roberts [43]	2015	5.70 (−4.37; 15.77)	-	1.14 [0.48; 2.73]	-	-	1.3 [−2.91; 5.51]	NA	-
22	Aunan [44]	2016	0.00 (−7.25; 7.25)	Symptoms: 4.0 [−0.15; 8.15] ADL: 5.0 [−0.71; 10.71] Sport: 10.0 [0.68; 19.32]	-	VAS: 2.0 [−3.35; 7.35] KOOS: 6.0 [0.45; 11.5]	−1.0 [−3.25; 1.25]	-	NA	-
23	Ali [45]	2016		Symptoms: −1.0 [−6.47; 4.47] ADL: −2.0 [−8.95; 4.95] Sport: −7.0 [−18.85; 4.85]	-	VAS: 1.0 [−5.61; 7.61] KOOS: −3.0 [−8.02; 2.02]	-	-	NA	-
24	Vukadin [46]	2017	1.43 (−0.32; 3.18)	-	-	1.0 [−5.61; 7.61]	0.07 [−1.02; 1.16]	-	NA	-
25	Dong [47]	2018	0.91 (−4.38; 6.20)	-	0.89 (0.38; 2.11)	-	-	-	Feller score	0.39 [−0.99; 1.77]
26	Jia [48]	2018	0.87 (−8.86; 10.20)	-	0.46 (0.18; 1.15)	-	-	-	NA	-
27	Kaseb [24]	2018	−3.98 (−13.10; 5.14)	1.53 [−8.28; 11.34]	-	VAS: −0.1 [−0.55 l 0.35] Anterior knee pain score: 2.48 [−3.81; 8.77]	-	-	WOMAC	5.01 [−3.99; 14.01]
28	Ha [49]	2019	2.27 (1.15; 3.39)	-	0.21 (0.07; 0.71)	-	-	-	Feller score	2.17 [1.23; 3.11]
29	Chawla [50]	2019	50.9 vs 47	-	-	-	-	-	NA	-
30	Kaseb [51]	2019	−0.65 (−11.40; 10.10)	-	-	-	-	-	NA	-
31	Thiengwit-tayaporn [52]	2019	-	-	0.20 (0.01; 4.05)	-	3.2 [0.4; 6.0]	2.7 [−2.18; 7.58]	Patellar score	1.2 [0.01; 2.39]
32	Koh [53]	2019	-	-	2.00 (0.38; 10.42)	-	-	-	Feller score	−0.7 [−1.95; 0.55]
33	van Raaij [54]	2021	4.6 (−10.07; 19.27)	Symptoms: −0.9 [−11.4; 9.6] ADL: −4.4 [−18.5; 6.7] Sport: −5.7 [−25.37; 13.9]	-	-	-	-	Baldini score	−6.2 [−17.3; 4.9]
34	Deroche [21]	2022	0.70 (−2.68; 4.08)	-	0.88 (0.44; 1.73)	-	-	−0.1 [−2.96; 2.86]	NA	-

Table 3 (continued)

No	Author	Year	KSS function	KOOS	Anterior knee pain	Knee pain scale	Oxford knee score	ROM	Other outcomes	
Observational										
1	Misra [55]	2003	-	-	1.19 [0.16; 8.82]	26.3 vs 26.8	-	105.8° vs 107.9°	HSS score (Pain and function scores separately) Function score	82.7 vs 84.4 17.6 vs 18.4
2	Garneti [56]	2008	72 ± 25.01 vs 75 ± 28.55	-	0.24 [0.08–0.69]	-	-	-	Knee instability Ability to kneel Walking aid Limp	1.09 [0.28–4.25] 0.9 [0.46–2.15] 0.84 [0.43–1.66] 2.5 [0.85–7.49]
3	Park [57]	2010	-	-	2.15 [0.08; 55.1]	-	-	128° vs130°	American Knee Society (Knee Score) American Knee Society (Functional Score) HSS Score	93.5 vs 95 77.5 vs 60 87 vs 83
4	Maradit [58]	2017	-	-	0.06 [0.003; 1.26]	-	-	-	NA	-
5	Weeks [59]	2018	-	-	-	-	-		Mean cost QALY	$12,917.01 vs $13,296.63 6.01 vs 5.37
6	Maney [60]	2019	-	-	-	-	6-mo: 36.92 vs 37.79 vs 38.57 5-yr: 40.02 vs 40.87 vs 41.34	-	NA	-
7	Butnaru [61]	2020	-	-	-	7 ± 2.3 vs 2 ± 2.0	79 ± 14.4	-	Forgotten Joint Score	63 ± 24.9
8	Thilak [62]	2020	70.9 ± 7.73 vs 66.44 ± 7.12	-	-	12.9 ± 2.72 vs 11.7 ± 3.44 (p 0.01)	-	-	Feller score Quadriceps (Feller sub.) Rise from chair (Feller sub.) Stair climbing (Feller sub.)	23.36 ± 1.63 vs 21.98 ± 1.70; p 0.01 4.3 ± 0.46 vs 4.4 ± 0.47; NS 3.0 ± 1.30 vs 3.1 ± 1.29; NS 3.1 ± 0.88 vs 2.8 ± 0.87; NS
9	Huish [63]	2020	-	-	-	2.5 vs 3.0	-	-	Oxford Knee Score Ability to kneel	39 vs 38 39% vs 64%
10	Ko [64]	2022	77.25 (45–100) vs 78.25 (45–100); NS	-	-	29.58 (0–70) vs 29.81 (0–70); NS	-	-	Feller score Kujala score SMC function	25.60 (14–30) vs 25.42 (13–30); NS 66.84 (44–97) vs 66.14 (39–97); NS 32.44 (0–62.5) vs 32.27 (0–62.5); NS

Table 3 (continued)

No	Author	Year	KSS function	KOOS	Anterior knee pain	Knee pain scale	Oxford knee score	ROM	Other outcomes	
11	Noh [65]	2022	90.9 ± 4.6 vs 91.5 ± 4.4	-	-	2.3 ± 1.5 vs 2.5 ± 1.5	-	128.1 ± 7.4 vs 127.5 ± 7.8	KSFS WOMAC total Kujala score Anterior knee pain (yes:no) Patellar compression test (positive:negative)	82.5 ± 5.2 vs 83.0 ± 4.9 16.6 ± 3.4 vs 16.7 ± 3.8 80.4 ± 8.6 vs 79.7 ± 11.5 11:239 vs 19:231 7:234 vs 20:230
12	Abbot [66]	2023	-	-	-	1.36 vs 1.29; NS (1 year) 1.41 vs 1.37; NS (2 year)	36.5 ± 9.3 vs 36.4 ± 9.3; NS (1 year) 16.3 ± 9.5 vs 16.1 ± 9.7; NS (2 year)	-	Stair descend (OKS change) Ability to kneel (OKS change)	1.24 vs 1.15; p 0.019 (1 year) 1.23 vs 1.17; NS (2 year) 0.77 vs 0.79; NS (1 year) 0.75 vs 0.79; NS (2 year)
13	Samih [4]	2023	164.2 vs 161.8	-	-	-	-	-	Flexion	108° vs 109°
14	Robben [67]	2023	-	0.14 [−0.36—0.64]	-	3.8 ± 3 vs 3.7 ± 2.9; MD 0.06 [−0.01—0.14] 5.1 ± 2.9 vs 5 ± 2.9; MD 0.02 [−0.07-0.1]	15.4 ± 9.1 vs 15.4 ± 8.8; MD 0.30 [0.03–0.56]	-	NA	-
15	Gerow [68]	2024	-	50.0 vs 29.7	-	-	-	-	NA	-

Table 4 Descriptive of the Mean Cost and QALY along with their Incremental Data of Comparison Between Resurfacing vs. No-resurfacing

No	Author	Year	Cost (£)		Incremental Cost (SE)	QALY		Incremental QALY	ICER	INB (£30,000 per QALY)	Variance INB
			Resurfacing	Non-resurfacing		Resurfacing	Non-resurfacing				
1	Weeks [59]	2018	10,211	10,512	−301 (287.6)	6.01 (1.9)	5.37 (3.1)	0.64 (3.64)	−468.94	19,501	11,861,910,874
2	Murray [42]	2014	8,785	8,889	−104 (268.6)	5.29 (0.07)	265.11 (0.08)	0.18 (0.10)	−577.78	5,504	8,829,218
3	Breeman [26]	2011	7,577	7,726	−149 (217.6)	6.3 (3.4)	6.1 (3.4)	0.2 (4.81)	−745	6,149	20,759,737,990

Study or Subgroup	Mean Difference	SE	Weight	Mean Difference IV, Random, 95% CI
Aunan 2016	0	3.699	4.4%	0.00 [−7.25, 7.25]
Burnett 2004	−0.8	5.6277	2.9%	−0.80 [−11.83, 10.23]
Burnett 2009	−6	5.6634	2.9%	−6.00 [−17.10, 5.10]
Deroche 2022	0.7	1.7245	6.2%	0.70 [−2.68, 4.08]
Dong 2018	0.91	2.699	5.3%	0.91 [−4.38, 6.20]
Ferguson(b) 2014	2.2	3.1021	4.9%	2.20 [−3.88, 8.28]
Ferguson 2014	4	3.4746	4.6%	4.00 [−2.81, 10.81]
Garneti 2008	−3	4.5366	3.7%	−3.00 [−11.89, 5.89]
Ha 2019	2.27	0.5714	6.9%	2.27 [1.15, 3.39]
Jia 2018	0.87	4.9644	3.3%	0.87 [−8.86, 10.60]
Kaseb 2018	−3.98	4.6531	3.6%	−3.98 [−13.10, 5.14]
Kaseb 2019	−0.65	5.4848	3.0%	−0.65 [−11.40, 10.10]
Liu 2012	3.6	3.0052	5.0%	3.60 [−2.29, 9.49]
Myles 2006	−15.6	5.0766	3.3%	−15.60 [−25.55, −5.65]
Roberts 2015	5.7	5.1378	3.2%	5.70 [−4.37, 15.77]
Schroeder−Boersch 1998	16.9	6.3113	2.5%	16.90 [4.53, 29.27]
Smith 2008	−10	1.0153	6.7%	−10.00 [−11.99, −8.01]
Thilak 2020	4.46	1.4833	6.4%	4.46 [1.55, 7.37]
van Raaij 2021	4.6	7.4848	2.0%	4.60 [−10.07, 19.27]
Vukadin 2017	1.43	0.8929	6.8%	1.43 [−0.32, 3.18]
Waters 2003	2.6	2.4796	5.5%	2.60 [−2.26, 7.46]
Wood 2002	5	0.7041	6.9%	5.00 [3.62, 6.38]
Total (95% CI)			**100.0%**	**0.67 [−1.77, 3.12]**

Heterogeneity: $Tau^2 = 22.12$; $Chi^2 = 182.94$, df = 21 ($P < 0.00001$); $I^2 = 89\%$
Test for overall effect: Z = 0.54 (P = 0.59)

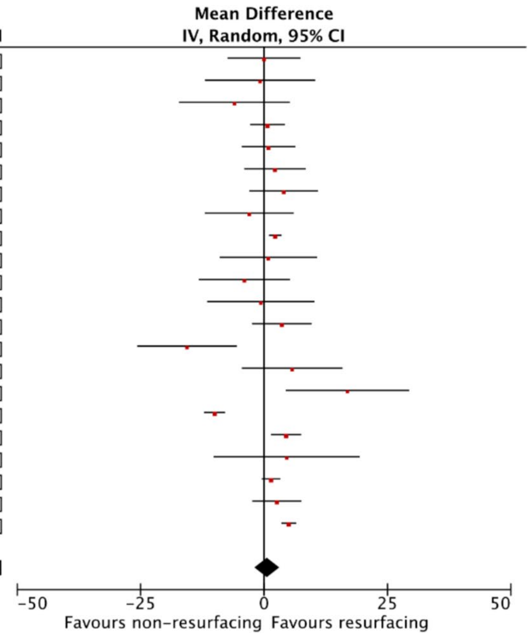

Fig. 3 Forest plot of Knee Society Score (KSS) function between patellar resurfacing vs non-resurfacing in TKA

Anterior knee pain after surgery occurred in 0–30.1% of resurfaced cases, compared to 4.35–47% in those without resurfacing [16]. Tang et al. (2023) also reported significantly less anterior knee pain in the resurfacing group (RR 0.72; 95% CI 0.57–0.91; p= 0.006) [16]. In contrast, Chen et al. (2021) found no significant difference in anterior knee pain between groups. [71]

It needs to be highlighted that despite significantly lower anterior knee pain was seen in patellar resurfacing, subgroup analysis (Fig. 7) showed non-significant difference between resurfacing and non-resurfacing in Asian, American, and Australian subgroups. Previous study showed that difference in anterior knee pain between patellar resurfacing and non-resurfacing diminished after 1-year [16]. This may be caused by new onset knee pain, which cannot be anticipated by solely patellar resurfacing. Also, there were other factors associated with anterior knee pain other than patella, such as malalignment, malrotation of femoral or tibial component, instability, dynamic valgus, ligament insufficiency, muscle imbalances, or patellar-femoral compartment overstuffing [16, 71]. Persistent anterior knee pain was also seen following patellar resurfacing, which may be attributable to alteration in patellofemoral kinematics commonly seen after resurfacing [72]. Furthermore, residual patella bone thickness of less than 12 mm was associated with higher risk of stress fracture, which may paradoxically resulted in higher risk of knee pain [69].

Pain scores assessed by both VAS and WOMAC did not significantly differ between resurfacing and non-resurfacing groups, suggesting comparable subjective pain relief.

Regarding joint functionality, we evaluated postoperative ROM following patellar resurfacing and non-resurfacing in TKA. Grela et al. also showed no significant difference in ROM between patellar resurfacing and non-resurfacing. [70] Previous study reported that postoperative ROM following TKA were associated with age, preoperative flexion angle, preoperative flexion arc, and preoperative tibiofemoral angle [73]. Patellar resurfacing may affect ROM. One study found that increasing patellar thickness by 2 mm could reduce ROM by 2°. This can be avoided by restoring native patellar thickness during surgery [74]. However, this outcome can be anticipated by ensuring native patellar thickness during surgery.

In terms of patient-reported outcomes, we evaluated KSS function and Oxford Knee Score between patellar resurfacing and non-resurfacing. We found significantly higher KSS function in patellar resurfacing in European subgroup. Our result was consistent with previous meta-analysis [16, 70, 71, 75]. Our findings are partially consistent with earlier systematic reviews. Tang et al. reported a significant reduction in anterior knee pain with patellar resurfacing, which aligns with our results. In contrast, Chen et al. concluded that resurfacing showed no significant advantage in anterior knee pain, range of motion, or KSS function. Previous research by Di Martino et al. also showed higher bone mineral density in non-resurfaced patella, which correlated with significant improvement of knee functional score. [76] A possible reason for this

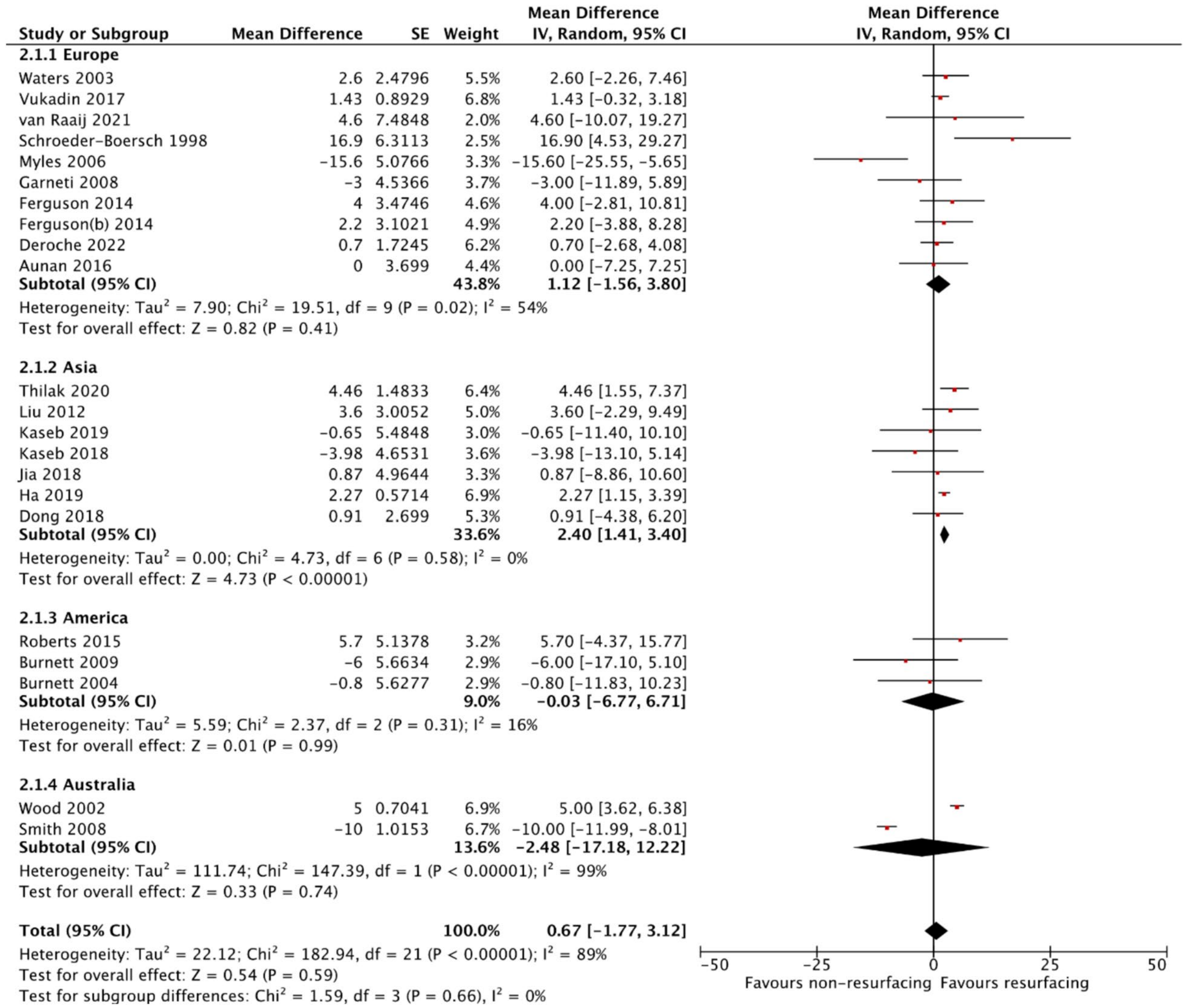

Fig. 4 Subgroup analysis of KSS function based on country origin

discrepancy is that our review included more recent studies published between 2020 and 2024, as well as observational data, which expanded the evidence base and allowed for broader real-world applicability. Unlike Chen et al. and Di Martino et al., we included studies across various healthcare settings and study designs, which may better reflect clinical practice and patient diversity. [19]

Other than functional outcomes, the benefit of patellar resurfacing has been reported by other studies in terms of rate of revision surgery. Previous meta-analysis reported significant reduce in patellar and non-patellar revision in patellar resurfacing until up to 10 years [16, 77]. Other data from Australian registry showed a 1.4% higher rate of revision surgery related to anterior knee pain in TKA without patellar resurfacing [78]. However, contrary to other studies, Maney et al. reported no difference in revision rates between resurfacing and non-resurfacing. [60]

From the perspective of patient functional outcomes linked to economic aspects, specifically the costs incurred by the patient and the impact on their quality of life, our analysis concludes that there is no significant difference between the resurfacing and non-resurfacing groups in TKA, as reflected in the INB data. This finding is consistent with the study by Breeman et al. [26], which presented results in terms of mean cost. However, significant differences in mean cost and QALYs were found in the studies by Murray et al., Weeks et al., and Parsons et al. [42, 76, 79], all of them indicated that resurfacing may be more cost-effective. It is important to note, however, that only three studies provided sufficient data for pooling INB and QALY outcomes. The small number of economic evaluations limits the robustness and external validity of our findings. Furthermore, the studies were conducted in healthcare systems with

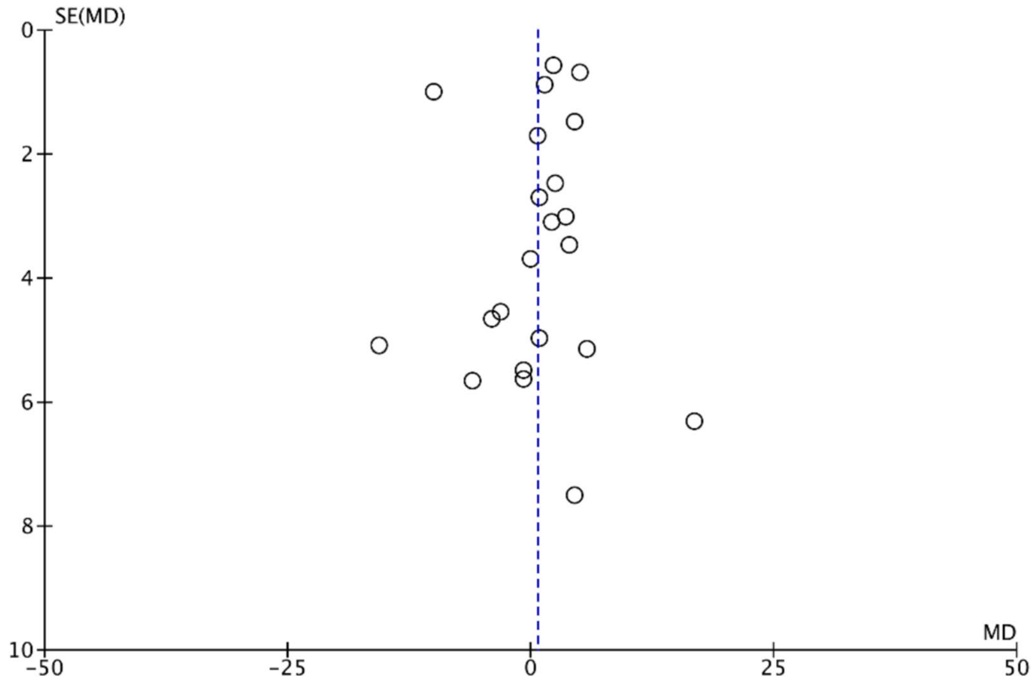

Fig. 5 Funnel plot for KSS function outcome

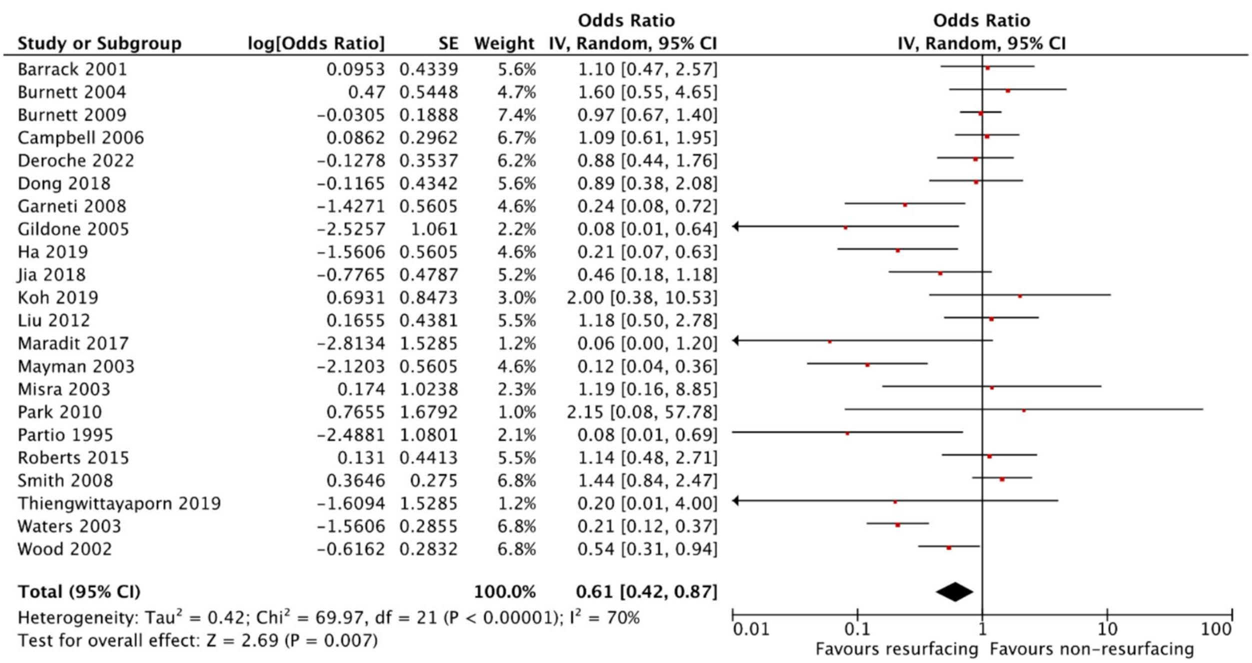

Fig. 6 Forrest plot of anterior knee pain outcomes between patellar resurfacing vs non-resurfacing in TKA

distinct reimbursement structures and cost baselines (e.g., UK and Canada), which may not reflect the economic realities of other regions, particularly low- and middle-income countries. As such, generalizing these cost-effectiveness results should be done with caution. Future real-world economic evaluations using standardized cost-effectiveness metrics across diverse populations are needed to confirm these preliminary findings.

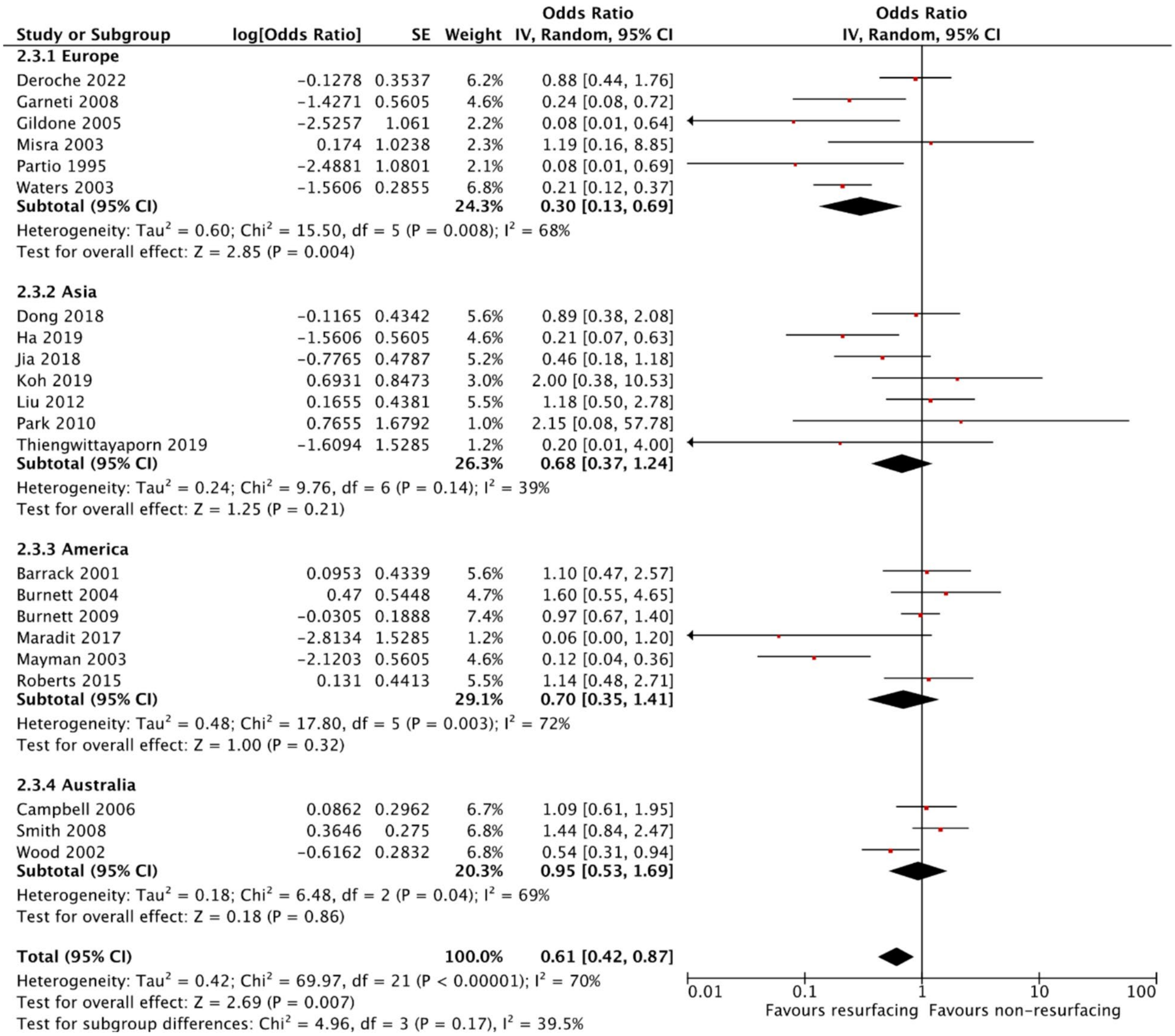

Fig. 7 Subgroup analysis of anterior knee pain outcomes based on country origin

Choice of whether patellar resurfacing should be performed may be influenced by multiple factors, such as age, body mass index, previous mobility, type of implant used in TKA, presence of preoperative anterior knee pain, presence of inflammatory arthritis, and condition of patella articular cartilage. For instance, patients with inflammatory arthritis and obese should be performed with patellar resurfacing in TKA due to higher risk of anterior knee pain. When decision has been made for patellar resurfacing, restoration of native patellar thickness is important to achieve optimal postoperative ROM [59, 80].

Compared to previous meta-analyses, we have included newer studies regardless of study design (including observational studies) and language, which broadened the scope of the review. However, there are several limitations. Chief among them is the insufficient control of potential confounding variables across the included studies. Critical patient-level factors such as age, body mass index (BMI), preoperative anterior knee pain, the presence of inflammatory arthritis, and patellar cartilage status were not uniformly adjusted for or stratified. These variables are known to influence both functional outcomes and pain perception following TKA. For instance, patients with obesity or inflammatory joint disease may be more likely to benefit from patellar resurfacing due to increased stress on the anterior compartment. The absence of stratified subgroup analyses or multivariate adjustments for these parameters may have obscured differential treatment effects,

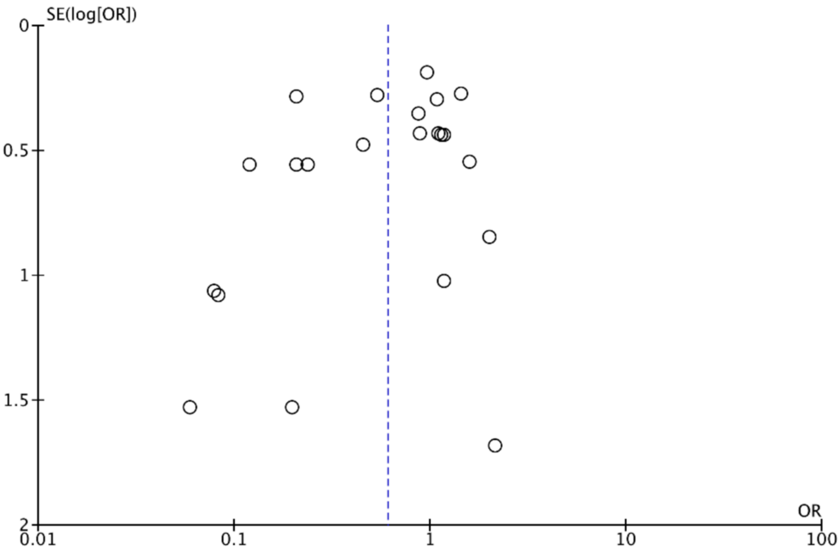

Fig. 8 Funnel plot for anterior knee pain outcome

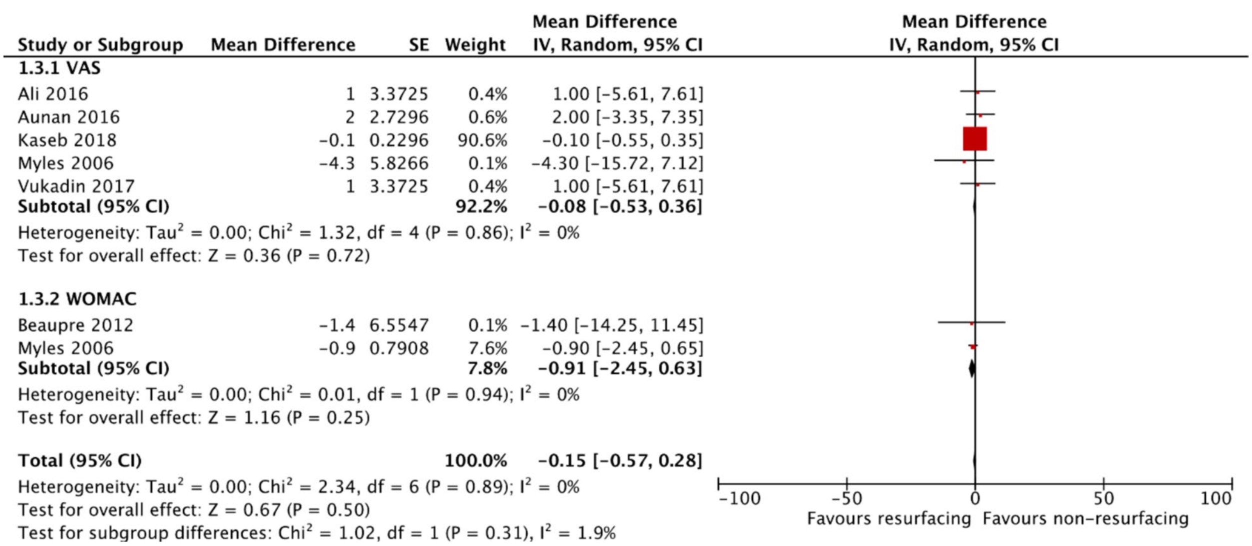

Fig. 9 Forrest plot of knee pain outcomes using VAS and WOMAC between patellar resurfacing and non-resurfacing in TKA

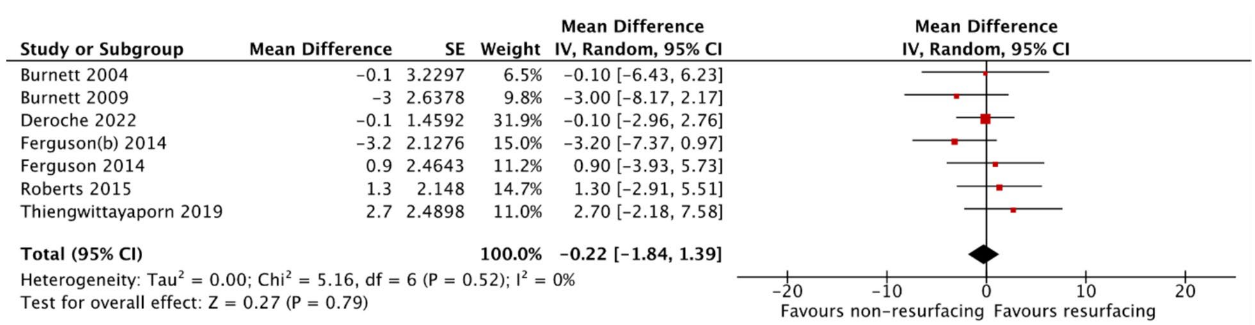

Fig. 10 Forrest plot of ROM outcomes between patellar resurfacing and non-resurfacing in TKA

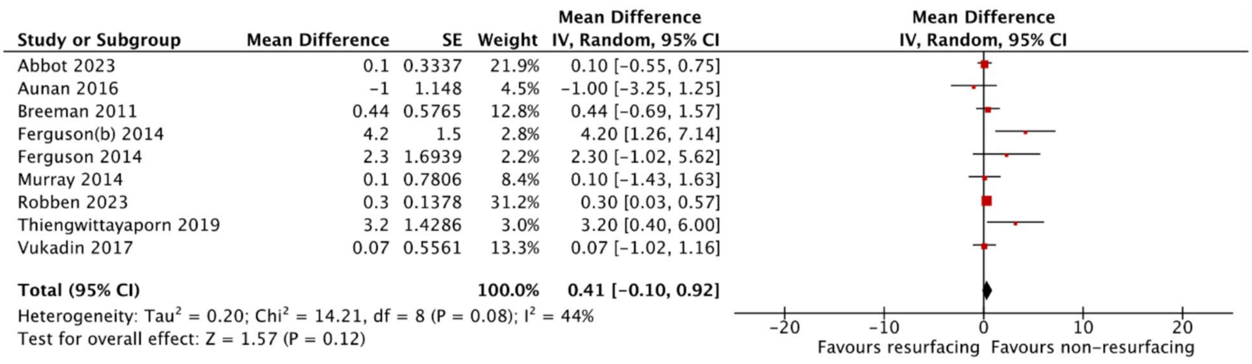

Fig. 11 Forrest plot of Oxford Knee Score outcomes between patellar resurfacing and non-resurfacing in TKA

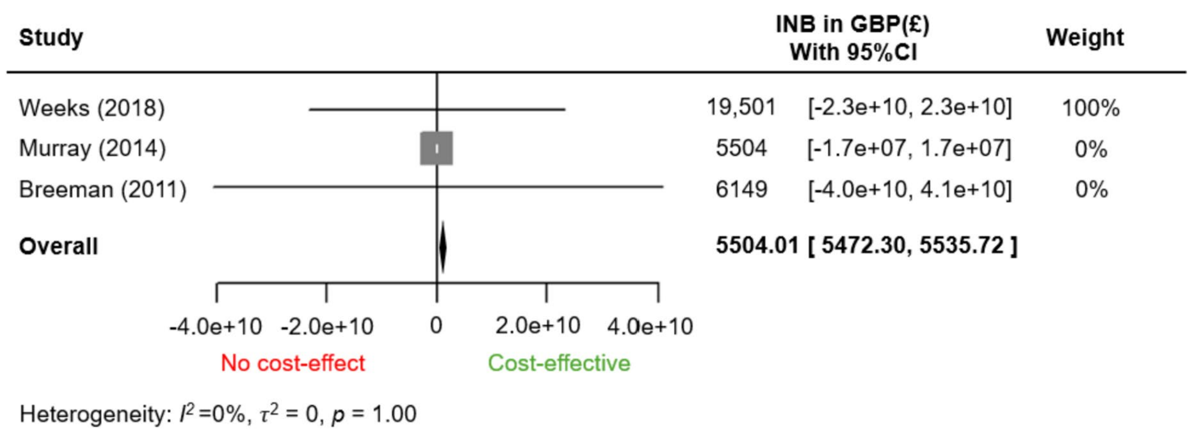

Fig. 12 Forest plot of pooling INBs of Resurfacing vs. No-resurfacing

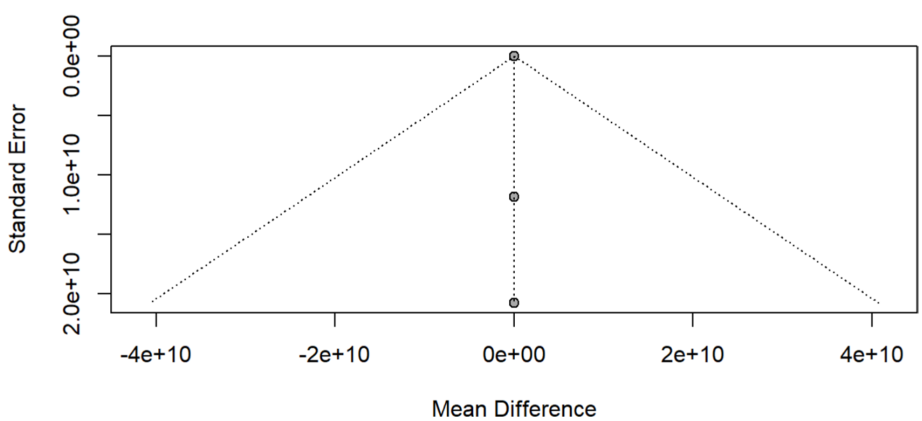

Fig. 13 Funnel plot of pooling INB of Resurfacing vs. No-resurfacing

thereby reducing the reliability and internal validity of the pooled estimates. Future high-quality RCTs should consider incorporating these factors into study design and analysis to improve the robustness of comparative conclusions.

The substantial heterogeneity observed in outcomes such as KSS function (I^2= 89%) may be attributed to variations in surgical technique, implant design, patient populations, and follow-up durations across studies. This level of heterogeneity indicates that pooled estimates should be interpreted with caution. It suggests that individual patient characteristics, implant designs, and surgical techniques may significantly influence outcomes—highlighting the need for personalized decision-making rather than one-size-fits-all recommendations. Differences in healthcare systems and rehabilitation protocols may have also contributed to outcome variability [16, 19, 70]. Although random-effects models were used to account for this variability, these factors likely contributed to the high heterogeneity and limit the generalizability of the findings.

Future studies may investigate the long-term effects of patellar resurfacing on functional outcomes, pain perception, and revision rates in TKA patients. Confounding factors and patient-specific factors (i.e. implant type, preoperative mobility, and comorbidities) should also be evaluated as determining factor in decision of patellar resurfacing in TKA. Clinicians should consider patient-specific factors such as preoperative anterior knee pain, BMI, diagnosis (e.g., inflammatory arthritis), and expected implant performance when deciding on patellar resurfacing. In settings with high resource constraints, a selective resurfacing strategy guided by these clinical predictors may offer an optimal balance between outcomes and cost-effectiveness.

Conclusion

This meta-analysis demonstrated that patellar resurfacing in total knee arthroplasty significantly reduces anterior knee pain compared to non-resurfacing. However, no meaningful differences were found in functional outcomes such as KSS function, pain scales, Oxford Knee Score, range of motion, or cost-effectiveness as measured by Incremental Net Benefit (INB). Given these findings, the decision to perform patellar resurfacing should be individualized, taking into account clinical factors (e.g., preoperative anterior knee pain, diagnosis, BMI) as well as institutional cost considerations. Tailoring surgical strategy to patient profiles and healthcare resource availability may optimize both clinical and economic outcomes.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-05892-z.

Supplementary Material 1

Authors' contributions

MAU conceptualized and supervised the study, contributed to the investigation, and managedproject administration. HY and SFZA developed the methodology, with SFZA also handlingsoftware implementation, formal analysis, data validation (alongside MAU), visualization, andoriginal draft preparation. NR curated data, reviewed and edited the manuscript with SFZA, andprovided supervision. HY contributed resources, while SFZA secured funding for the study.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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