



Beyond one step: unveiling optimal approach for bilateral knee arthroplasty - a comprehensive meta-analysis

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Abstract

Background Total knee arthroplasty (TKA) is an efficient and common procedure used to treat advanced osteoarthritis of the knee. Geriatric patients make up the majority of TKA patients. For the surgical management of bilateral knee arthritis, there is still debate regarding whether to do a simultaneous or staged TKA. We through this study have gathered data and aimed to assess the safety of simultaneous bilateral TKA in patients.

Materials and methods We conducted a study according to the PRISMA guidelines by searching through various databases for the following search terms: total knee arthroplasty (TKA), complications following TKA, bilateral TKA, and bilateral vs. unilateral TKA. The search included case series and clinical trials and excluded review articles, yielding 24 articles from the original search. We extracted data upon the outcomes in patients undergoing simultaneous bilateral TKA. We performed additional bias assessments to validate our search algorithm and results.

Results One hundred and three published articles were identified, and twenty-four that included a total of 2, 18,385 patients were included in the meta-analysis. 93,074 patients underwent simultaneous bilateral TKA and 125,311 patients underwent staged bilateral TKA. Simultaneous bilateral TKA was associated with significantly increased mortality rate ($P < 0.00001$, Odd's ratio [OR] 1.86, 95% Confidence interval [CI] 1.53–2.26), increased incidence of pulmonary embolism ($P < 0.00001$, OR 1.58, 95% CI 1.30–1.91), deep venous thrombosis ($P < 0.00001$, OR 1.31, 95% CI 1.17–1.46), and neurological complications ($P < 0.002$, OR 1.44, 95% CI 1.14–1.82). There were no significant differences in cardiac complications between both the procedures ($P = 0.60$, OR 0.93, 95% CI 0.70–1.23).

Conclusion Staged bilateral TKA is associated with less complication rates as compared to simultaneous bilateral TKA. Hence, patients should be counselled and selected based on the risks respective to each strategy.

Keywords Total knee arthroplasty · Bilateral · Staged · Simultaneous · Deep venous thrombosis · Pulmonary embolism

Introduction

Total knee arthroplasty (TKA) is an efficient and common procedure used to treat advanced osteoarthritis of the knee. Geriatric patients make up the majority of TKA patients, with insurance beneficiaries accounting for around 75% of

TKA procedures [1]. According to Cram et al. [2], between 1991 and 2010 there was a 161% rise in yearly TKA volume. This rise is attributable to the elderly population's improvement in function, independence, and pain as well as the growing acceptance of invasive therapy [3, 4]. For the surgical management of bilateral knee arthritis, there is still debate regarding whether to do a simultaneous or phased total knee arthroplasty. When the procedure is performed at the same time, there is a higher risk of significant complications or even death, according to various studies. However, some researchers are of the opinion that there is little to no evidence linking simultaneous TKA to an increase in risks or complications. There have been inconsistent findings when simultaneous bilateral TKA and staged bilateral TKA have been compared in a few randomized and nonrandomized controlled trials [5–8].

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After having a complete knee arthroplasty, four out of five patients are satisfied with the results [6]. However, geriatric patients with comorbidities may have higher risks and expenditures, which could prevent them from having as many elective orthopaedic surgeries. Patients who are 85 years or older are 41% less likely than younger patients to undergo TKA [1]. Older patients who did not have surgery made up nearly half of those who were not given TKA [7]. Age has a variable impact on surgical outcomes, according to previous studies [7–11], and there is no clear relationship between age and TKA candidacy.

Because of ethical concerns, it is challenging to conduct a controlled randomized trial of patients with bilateral knee arthritis. Furthermore, because patients with higher comorbidity are frequently thought to be undesirable candidates for simultaneous TKA and are typically excluded from studies of those procedures, many of the research addressing the problems linked to bilateral TKA may have selection bias. Last but not least, and perhaps most significantly, the majority of the studies had rather small sample sizes and were likely underpowered to detect differences between the two treatments choices due to the relative rarity of serious complications following TKA.

Through meta-analysis, data can be gathered to address important issues like the safety of bilateral TKA in patients over 75 years of age. We gathered the available published data using stringent selection criteria to see if the occurrence of severe complications and mortality varied between bilateral and staged TKA. To assess the safety of simultaneous bilateral TKA compared with staged bilateral TKA in patients, all randomized and nonrandomized trials that compared the two procedures were considered. A more accurate method of patient selection would be made possible by a greater comprehension of the advantages and disadvantages of TKAs in this group. In order to clarify the effect of age on total knee arthroplasty, we systematically reviewed and evaluated studies that investigated the association of age on surgical outcomes.

Materials and methods

Study selection and information source

In this study, we adhered to the PRISMA 2020 guidelines and the Cochrane Handbook for systematic reviews and meta-analyses [12, 13]. We conducted a comprehensive literature search using EMBASE, PubMed (MEDLINE), Cochrane, and Google Scholar to find peer-reviewed articles on bilateral TKA. Additionally, we manually searched the references of relevant articles, tables of contents from major orthopedic journals (2010–2023), and bibliographies

of key arthroplasty textbooks, including “The Adult Knee,” “Campbell’s Operative Orthopaedics,” and “Joint Replacement Arthroplasty.”

We screened study titles and abstracts for potential inclusion, considering all studies comparing the safety of simultaneous bilateral TKA with staged bilateral TKA, irrespective of diagnosis, surgical approach, or prosthesis type. For studies with overlapping patient populations, the one with the longest follow-up was selected. Data on population characteristics, interventions, and outcomes were extracted, though variables such as weight, race, BMI, comorbidities, prior knee surgeries, surgical methods, anesthesia techniques, perioperative antibiotics, thromboembolic prophylaxis, and postoperative rehabilitation details were inconsistently reported. Our primary outcomes were mortality and major complications, including deep vein thrombosis, pulmonary embolism, neurological complications, and cardiac issues.

Data extraction

Every relevant detail that was presented in the studies was extracted after an independent evaluation, including but not limited to demographics, prior procedures, and information on thromboembolic and infection prevention, patient satisfaction, functional outcome, and complication rate. In each report, details were obtained regarding the characteristics of the investigated population. The number of patients who underwent a simultaneous or staged procedure, as well as any complications that were indicated and the requirement for revision surgeries, were also noted.

Statistical analysis

Odd ratios (ORs) or standard mean differences (SMDs) with associated 95% confidence intervals (CI) were estimated and pooled across trials to evaluate the disparity between the 2 approaches, with a value of $P < 0.05$ being considered significant. Using a forest plot, the meta-analysis of relevant variables was graphically summarized.

Publication bias was assessed by ROBIS tool. All analyses were performed using the RevMan 5.3 software.

The last search was done in September 2023, and the following search terms were used: total knee arthroplasty (TKA), complications following TKA, bilateral TKA, and simultaneous bilateral vs. staged bilateral TKA. Additionally, we looked for any potentially pertinent studies using the “related articles” option. This method of searching produced 751 non-duplicated articles [Fig. 1].

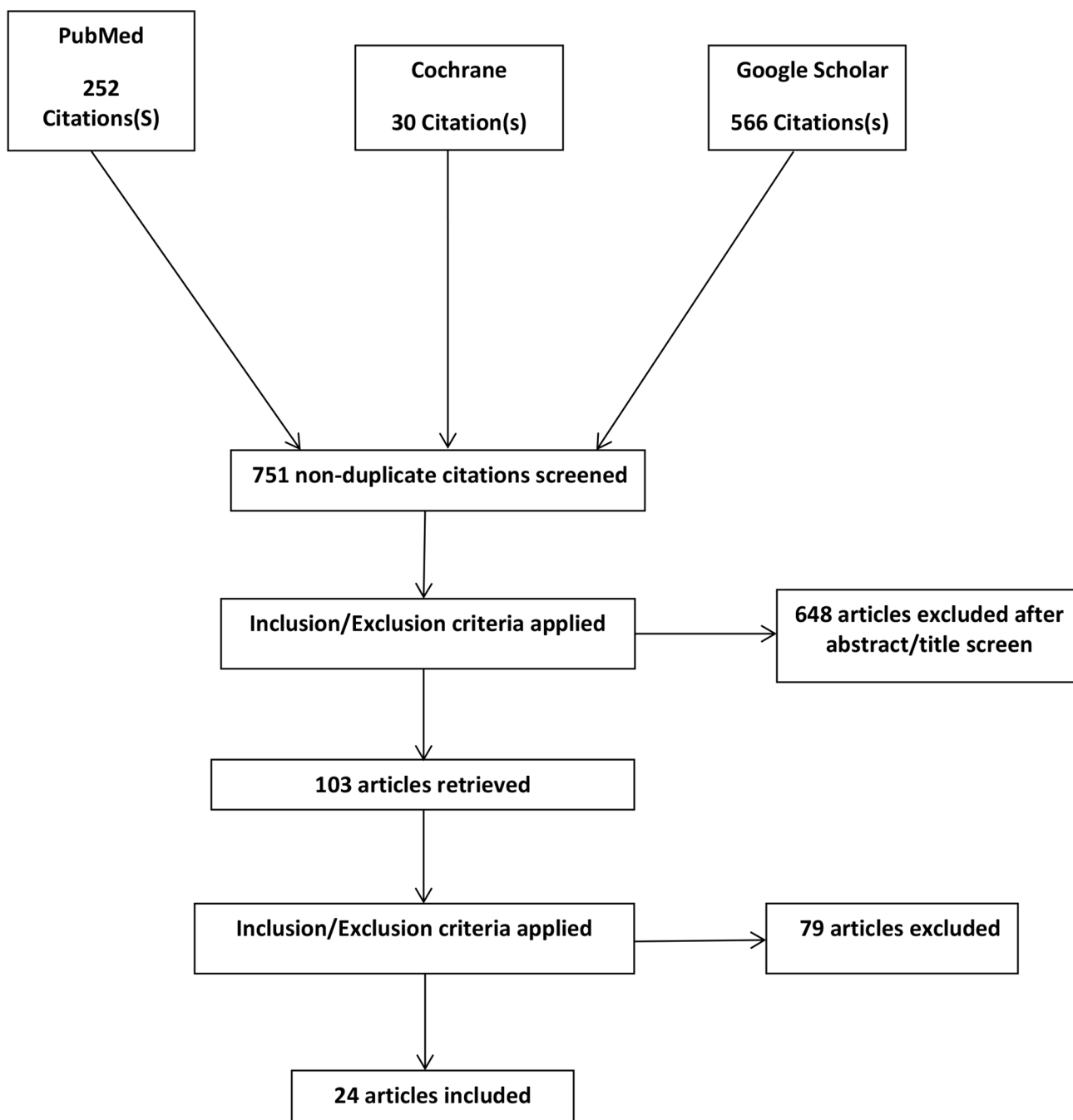


Fig. 1 PRISMA flowchart of the Meta-analysis

Results

In the search for research on the variables that affect Simultaneous bilateral TKA in patients, 848 citations were found; 751 citations were included after screening for duplicates. When inclusion and exclusion criteria were applied to abstracts, 648 articles were eliminated from the review. Following the application of inclusion and exclusion criteria to 103 full-length manuscripts, 24 articles were selected for

review. Table 1 shows the relevant findings from these 24 publications.

The risk of bias was assessed using the ROBIS tool, and the findings revealed that the methods and outcomes of the literature search qualified for a low risk of bias [Table 2].

Table 1 Characteristic Features of the Included Studies

Sr. No	Authors	Year of Publication	Study Design	Simultaneous Bilateral TKA		Staged Bilateral TKA	
				N(n)	Mean Age (Years)	N(n)	Mean Age (Years)
1	Mangaleshkar et al. [14]	2001	Retrospective	54	73	34	71.7
2	Ritter et al. [15]	2003	Retrospective	2050	69.9	152	69.2
3	Stubbs et al. [16]	2005	Retrospective	61	64	38	67
4	Silva et al. [17]	2005	Retrospective	26	59.3	306	67.2
5	Hutchinson et al. [18]	2006	Prospective	438	67	125	65
6	Barett et al. [19]	2006	Retrospective	8324	NA	13,039	NA
7	Walmsley et al. [20]	2006	Retrospective	826	NA	1796	NA
8	Forster et al. [21]	2006	Retrospective	28	66	36	68
9	Stefansdottir et al. [22]	2008	Retrospective	1139	70.4	3432	71.2
10	Yoon et al. [23]	2010	Retrospective	119	70	119	70
11	Meehan et al. [24]	2011	Retrospective	11,445	67.2	23,715	67.7
12	Bolognesi et al. [25]	2013	Retrospective	4519	73.3	3788	67.7
13	Bini et al. [26]	2014	Retrospective	1230	66	2123	67
14	Courtney et al. [27]	2014	Retrospective	103	59.4	131	64.2
15	Niki et al. [28]	2014	Prospective	60	73	60	72.3
16	Lindberg-Larsen et al. [29]	2015	Retrospective	157	64	628	66
17	Sheth et al. [30]	2016	Retrospective	2814	64.8	5177	67.4
18	Sobh et al. [31]	2018	Retrospective	225	61	337	68
19	Chua et al. [32]	2018	Retrospective	23,136	NA	12,951	NA
20	Koh et al. [33]	2018	Retrospective	820	68.6	633	69.7
21	Wyatt et al. [34]	2019	Retrospective	6440	NA	5116	NA
22	Tsay et al. [35]	2019	Retrospective	27,301	65.8	45,419	66.6
23	Richardson et al. [36]	2019	Retrospective	1637	NA	6110	NA
24	Gill et al. [37]	2020	Retrospective	122	70.6	46	70.7
				93,074		125,311	

Table 2 ROBIS Tool for assessing risk of bias in meta-analysis

	Study eligibility criteria	Identification and selection of studies	Data collection and study appraisal	Synthesis findings	Risk of bias in the review
Simultaneous Bilateral TKA in patients above 75 years of age	Yes	Yes	Yes	Yes	A. Yes
Meta-analysis					B. Yes C. No Overall: Low

TKA: Total Knee Arthroplasty

Eligible studies

A total of 24 articles were selected for inclusion in the meta-analysis [Table 1]. The published reports included information on 1, 86,054 patients. There were 2,18,385 patients included in the meta-analysis. 93,074 patients underwent simultaneous bilateral TKA, and 125,311 patients underwent staged bilateral TKA. Data on the rates of deep venous thrombosis in the two groups were provided by twelve articles [17, 18, 23–31, 35]. Thirteen articles reported on the prevalence of pulmonary embolism in the population under study [17, 18, 21, 23–31, 35]. The prevalence of cardiac complications was calculated using twelve trials [15–18,

24, 25, 27, 29, 30, 35–37]. Twenty studies provided data on the rate or prevalence of mortality in the sample [14, 15, 17, 18, 20–30, 32, 33, 35–37]. The two groups of patients were compared in terms of the prevalence of the five most serious complications: deep venous thrombosis, pulmonary embolism, cardiac events, neurological complications and mortality. The analysis revealed that, even though a large number of studies on this topic have been published, the overall conclusions are inconclusive. The reporting of the results, specifically the final odds ratio, varies significantly across the articles. The majority of the articles do not specify the exact age criteria for TKA.

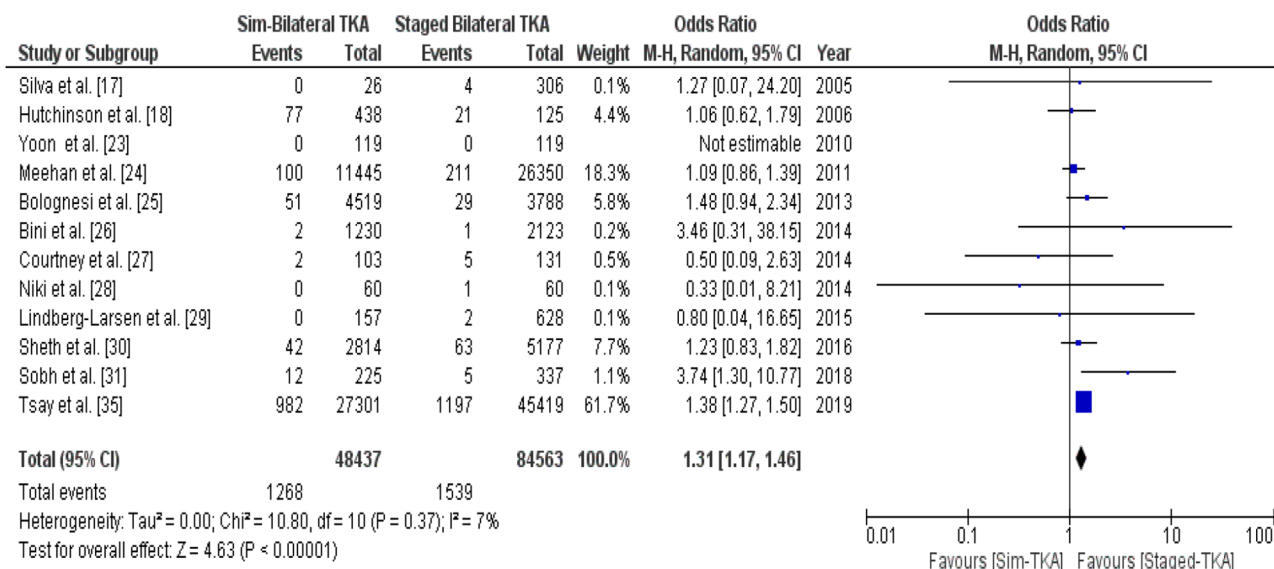


Fig. 2 Forest plot for Deep venous thrombosis following simultaneous bilateral total knee arthroplasty OR – Odd’s ratio, CI – Confidence interval, df – degree of freedom

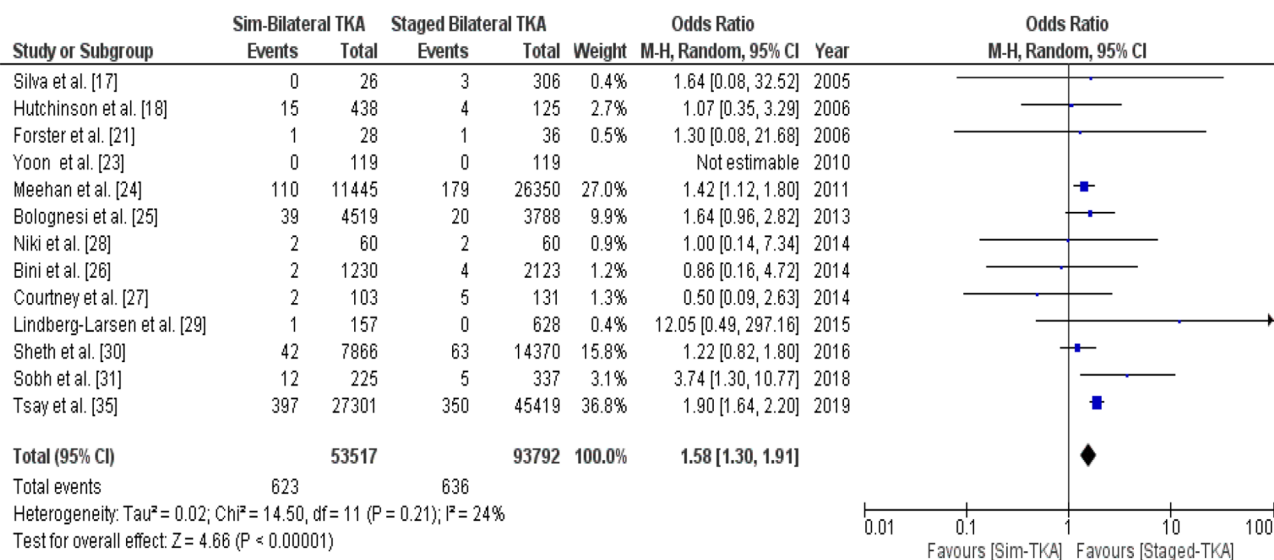


Fig. 3 Forest plot for Pulmonary embolism following simultaneous bilateral total knee arthroplasty OR – Odd’s ratio, CI – Confidence interval, df – degree of freedom

Deep venous thrombosis

The risk of a deep venous thrombosis event was lower in patients after staged bilateral TKA, and this finding was statistically significant (P value < 0.00001, Odds ratio [OR] 1.31, 95% Confidence interval [CI] 1.17–1.46) [Fig. 2]. The pooled odds ratio was 1.31 overall. For a sample size of 1,33,000 patients the highest odds ratio was 3.74 in a study that did not have a significant impact on the overall result.

Pulmonary embolism

Similar to the findings for deep venous thrombosis, the risk of pulmonary embolism was the higher in patients who had simultaneous bilateral TKA than in patients who had staged bilateral TKA (P value < 0.00001, OR 1.58, 95% CI 1.30–1.91) [Fig. 3]. Three of the articles made the most significant contributions to the overall calculation. After bilateral TKA, the highest odds ratio for pulmonary embolism was 12.05.

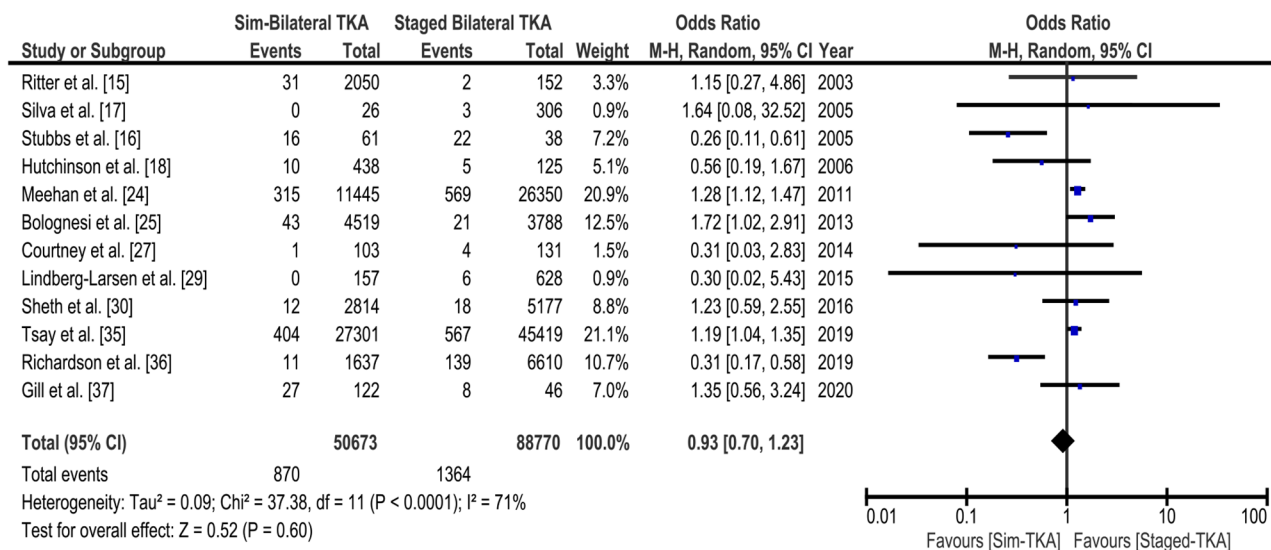


Fig. 4 Forest plot for Cardiac complications following simultaneous bilateral total knee arthroplasty OR – Odd’s ratio, CI – Confidence interval, df – degree of freedom

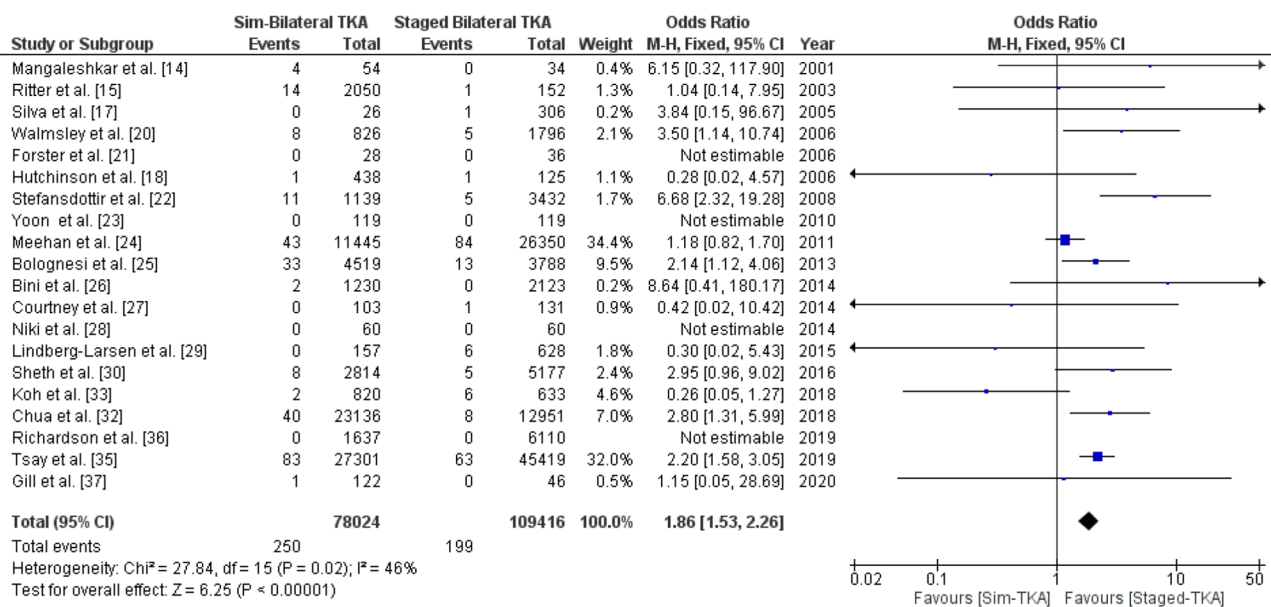


Fig. 5 Forest plot for Mortality following simultaneous bilateral total knee arthroplasty OR – Odd’s ratio, CI – Confidence interval, df – degree of freedom

Cardiac complications

The likelihood of cardiac complications varied little between groups as well. The analysis of twelve articles revealed no increase in the prevalence of cardiac events in patients who underwent simultaneous bilateral TKA as compared to staged bilateral TKA (P value = 0.60, OR 0.93, 95% CI 0.70–1.23) [Fig. 4]. The highest odds ratio recorded was 1.64.

Mortality

The prevalence of mortality significant in the population that had undergone simultaneous bilateral TKA as compared to those who underwent staged bilateral TKA (P value < 0.00001, OR 1.86, 95% CI 1.53–2.26) [Fig. 5].

Neurological complications

The prevalence of neurological complications were found to be higher in patients undergoing simultaneous bilateral TKA (P value < 0.002, OR 1.44, 95% CI 1.14–1.82) [Fig. 6].

Discussion

TKA remains one of the most effective orthopaedic surgical procedures and is considered extremely safe. Although the majority of patients with knee arthritis undergo unilateral TKA, patients with symptomatic arthritis of both knees are not uncommon. The orthopaedic surgeon must then determine whether bilateral simultaneous TKA is a safe procedure to perform in this circumstance. Furthermore, the majority of patients suffering from knee arthritis are over the age of 60 years. Simultaneous Bilateral TKA in these patients is still being debated. There is a need to decide whether simultaneous TKA in patients is safe.

There are numerous benefits to performing simultaneous bilateral TKA in patients during a single anaesthetic session. Some of the benefits of this approach include patient convenience, a shorter length of stay in the hospital, and a potentially shorter period of rehabilitation and disability. On the other hand, some surgeons are hesitant to perform simultaneous bilateral TKA during a single anaesthetic session due to concerns about increased complications. When an orthopaedic surgeon searches the literature for information on the safety of simultaneous bilateral TKA, he or she may come across contradictory results. The apparent conflict noted in the literature could be caused by a number of factors. Because complications like pulmonary embolism are uncommon, the majority of studies have a type-II statistical error due to a small patient

population. Furthermore, the effect of probable, and significant, selection bias cannot often be gleaned from these studies.

The investigators of a recent study attempted to overcome the aforementioned limitations by including a large patient sample [35]. In that study, patients who had simultaneous bilateral TKA had a higher incidence of pulmonary embolism than patients who had staged bilateral TKA. The incidence of pulmonary embolism in the first three months after arthroplasty was 1.45% in patients who had a single procedure compared to 0.77% in patients who had a staged bilateral TKA. Despite its strengths, this study suffered from the limitations inherent to analyses involving the Medicare database, as previously outlined. The Medicare database lacks important clinical information such as operative details. Hence, it was not possible for the investigators in that study to distinguish adequately between staged and simultaneous bilateral procedures.

As a result, this meta-analysis was carried out in order to combine data from a number of qualified studies in order to determine the prevalence of serious complications, including death, after bilateral TKA. The meta-analysis collected data and discovered that major complications such as pulmonary embolus, neurological events, deep venous thrombosis and death were significant after simultaneous bilateral TKA. The prevalence of cardiac complications appeared to be slightly lower after simultaneous bilateral TKA compared to staged bilateral TKA, but this difference was not statistically significant. This complication was not reported in all of the studies included in this meta-analysis. Although it was not a direct finding of this study, one could conclude that patients with concurrent cardiopulmonary conditions may not be good candidates for simultaneous bilateral TKA, even with recent advances in surgical and anaesthesia techniques.

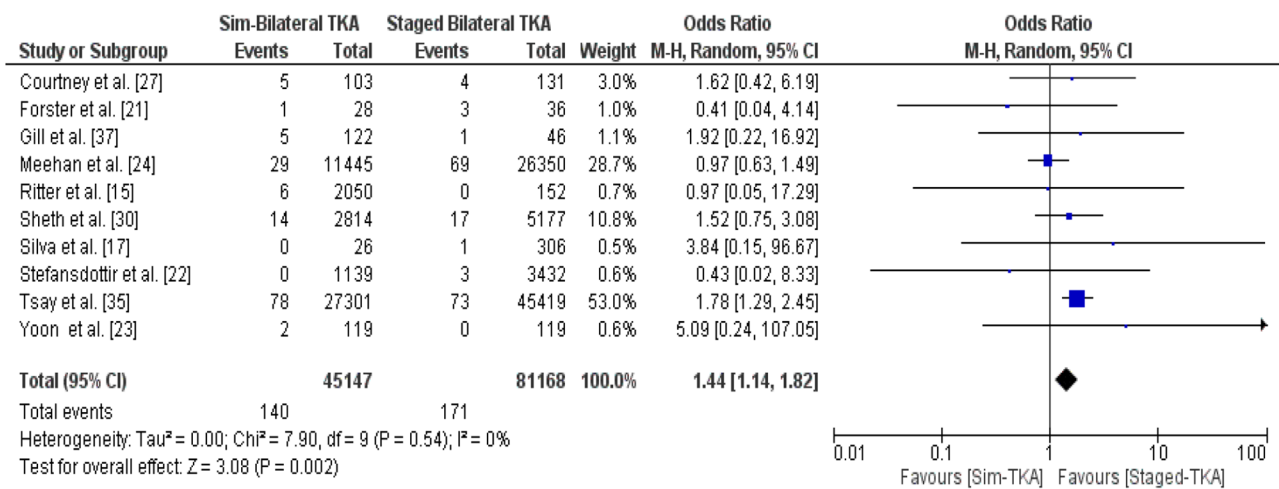


Fig. 6 Forest plot for Neurological complications following simultaneous bilateral total knee arthroplasty
OR – Odd’s ratio, CI – Confidence interval, df – degree of freedom

Limitations

This study thoroughly examines the existing research on simultaneous bilateral TKA vs. staged bilateral TKA and the complications associated with the procedure. This study is unusual in its methodology and findings since, to our knowledge, there aren't any reviews conducted in accordance with PRISMA standards that attempt to determine whether simultaneous bilateral TKA is safe patients. This study does, however, contain certain restrictions. Because of the difficulty in extracting the relevant information, this meta-analysis did not distinguish between simultaneous and staged bilateral total knee arthroplasty as a whole. Another potential limitation of this meta-analysis is related to the strict criteria for inclusion of randomized and comparative studies, as some potentially relevant studies may have been excluded. This step was necessary in order to eliminate important confounding variables. Finally, the meta-analysis was intended to evaluate the prevalence of major and life-threatening complications associated with simultaneous bilateral TKA. Hence, information on other complications such as periprosthetic infection or functional recovery was not sought. The majority of the studies did not provide information pertinent to these problems.

Based on our results, we recommend that the strategy for performing bilateral TKA should be carefully selected based on patient age, comorbidity profile and preference. Patients should be carefully counseled regarding the respective incidence of complications and consequent risks associated with each respective strategy. Further matched prospective studies comparing both clinical outcomes and patient reported outcomes following simultaneous bilateral TKA and staged bilateral TKA are required.

Conclusion

Staged bilateral TKA is associated with less complication rates as compared to simultaneous bilateral TKA. Hence, patients should be counselled and selected based on the risks respective to each strategy. However, there is a need for high-quality, prospective studies to better evaluate the clinical, functional and cost effectiveness of simultaneous bilateral TKA compared to staged bilateral TKA.

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Data availability This published article contains all the data generated

or analyzed during this study.

Declarations

Competing interests The authors declare no financial conflicts of interest to disclose.

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Consent for publication Not Applicable.

Informed consent Not Applicable.

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