Outcome Comparison Between Tranexamic Acid And Torniquet In Patients Undergoing Total Knee Arthroplasty: A Systematic Review

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KEYWORDS

Total Knee Arthroplasty, Tranexamic Acid, Torniquet

ABSTRACT:

IntroductionTotal knee arthroplasty (TKA) is coupled with severe blood loss. Numerous methods have been used to lessen intraoperative and postoperative blood loss, including Tourniquets and tranexamic acid (TXA). This study intended to investigate comparation using tourniquet only and Tranexamic acid (TXA) only in Total Knee Arthroplasty.

Objectives: We aim to know the efficacy of using tranexamic acid instead of torniquet in patients undergoing total knee arthroplasty.

Methods: This study, conducted in 2024, adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Articles were retrieved from databases including PubMed, ProQuest, and EBSCO with relevant studies focusing on TXA and torniquet use in patient underwent TKA. Study quality was assessed using the RoB 2 and JBI Critical Appraisal Tool, and meta-analysis was performed using a random-effects model in Review Manager version 5.4.

Results: The final analysis included five studies, revealing that TXA significantly reduced perioperative blood loss (MD = 573.34 mL, $p = 0.01$) compared to the tourniquet group, which had higher transfusion rates (OR = 7.52, $p < 0.01$) with no observed heterogeneity. While hemoglobin level changes favored TXA, hospital stay showed no significant difference between the two methods.

Conclusions: The use of tranexamic acid in TKA appears to offer advantages over tourniquet application in terms of reducing perioperative blood loss, lowering transfusion rates, and lowering length of stay patient. Although tourniquets remain useful in some cases, TXA's efficacy and safety suggest it may be a preferable choice in TKA procedures for optimizing blood management and patient recovery. Further standardized research is needed to refine best practices in TKA blood management.

1. Introduction

Total knee arthroplasty (TKA) is a popular and efficient surgical treatment for treating advanced osteoarthritis and other degenerative joint conditions. However, it is coupled with severe blood loss, which can cause postoperative anemia, an increased need for blood transfusions, and a longer recovery period.[1] Numerous tactics have been used to lessen intraoperative and postoperative blood loss in an effort to address this. Tourniquets and tranexamic acid (TXA) are two often employed therapies in this situation.[2,3]

Tranexamic acid is an antifibrinolytic drug that prevents the breakdown of fibrin clots, hence minimizing bleeding during and after surgery. Its ability to reduce blood loss without raising the risk of thromboembolic events has led to its widespread usage in TKA.[2] In contrast, tourniquets are mechanical devices that are put around the limb to reduce intraoperative bleeding during surgery by momentarily obstructing blood flow.[4,5]

Tourniquet use has been linked to possible side effects, such as increased postoperative pain, delayed recovery, and muscle injury, despite its effectiveness in minimizing blood loss during surgery.[4]

Despite the fact that both techniques have been demonstrated to decrease intraoperative blood loss, there is ongoing discussion on their relative efficacy and influence on significant postoperative outcomes, including recovery duration, pain thresholds, complication rates, and overall patient satisfaction.[6] Numerous research has evaluated the effects of these therapies separately, but the findings have been mixed. While some studies find no discernible differences between the two methods, others contend that tranexamic acid provides superior results in terms of reducing blood loss without the possible negative consequences of tourniquet use.

2. Objectives

This study conducts a systematic comparison of tranexamic acid (TXA) and tourniquet application in total knee arthroplasty (TKA) to evaluate their effectiveness in perioperative blood management and postoperative recovery. The analysis focuses on quantifying perioperative blood loss, transfusion requirements, hemoglobin level variations, and hospital length of stay. By synthesizing data from multiple studies, this research aims to determine the relative efficacy and safety of these hemostatic interventions, providing evidence-based recommendations for optimizing clinical outcomes in TKA procedures.

3. Methods

This systematic review was performed based on Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.

Eligibility Criteria

Studies were included if they met the following criteria:

1. Study Design: Randomized controlled trials (RCTs), prospective or retrospective cohort studies, case-control studies, and cross-sectional studies.
2. Population: Adult patients who underwent total knee arthroplasty.
3. Intervention: Tranexamic acid use
4. Comparator: Torniquet use
5. Outcomes: Postoperative blood loss, transfusion rates, changes in hemoglobin levels, length of hospital stay, and drainage output.

Search Strategy

A comprehensive and systematic search was conducted across multiple electronic databases including PubMed, EBSCO, ProQuest, and Google Scholar from their inception to October 2024. The search strategy incorporated both Medical Subject Headings (MeSH) and free text terms related to "total knee arthroplasty," "tranexamic acid," and "torniquet." References of the included studies and relevant review articles were also manually screened to identify additional eligible studies.

Data Selection, Collection, and Extraction

Two independent reviewers screened titles and abstracts of all retrieved studies. Full texts of potentially eligible studies were then assessed for inclusion. Discrepancies between reviewers were resolved through discussion, and if necessary, a third reviewer was consulted. Data extraction was performed independently by two reviewers using a pre-designed data extraction form. The extracted data included:

1. Study characteristics: authors, year of publication, country, study design.
2. Patient demographics: sample size, age, comorbidities.
3. Follow-up duration.

4. Outcomes: Postoperative blood loss, transfusion rates, changes in hemoglobin levels, length of hospital stay, and drainage output.

Quality Assessment

The quality of included studies was assessed using the RoB2 and JBI critical appraisal tool.

Data Analysis and Synthesis

A systematic qualitative synthesis was presented using text and tables to summarize and explain the characteristics and conclusions of the included studies, as well as to investigate their relationships. Meta-analyses were carried out using a fixed-effect model for low heterogeneity and a random effects model for high heterogeneity ($p<0.1$ or $I^2 \geq 50\%$) when the studies were sufficiently similar in terms of comparators and design. For dichotomous data, the treatment effects were quantified using the risk difference with a 95% confidence interval (CI). I^2 statistics were used to measure statistical heterogeneity. To assess publication bias, a funnel plot was used. Review Manager 5.4 statistical software was utilized to incorporate and examine pertinent data.

4. Results

Study characteristics

In total, 1849 studies were identified through database searches and manual searches (**Figure 1**). After removing duplicates, 1615 studies underwent an initial screening of titles and abstracts. Of these, 28 studies were further reviewed for eligibility, resulting in the final inclusion of 5 studies in the review. Most of the included studies had a retrospective design, with one prospective study and one RCT (**Table 1**). The surgical procedure examined across these studies is total knee arthroplasty (TKA), all studies involved the utilization of tourniquet, tranexamic acid, both, and control (not using both management). In general, the assessed outcomes across the studies are consistent. Blood loss can be measured in volume using the Gross formula, as seen in studies by Huang[7], Kurkreja[8], and Schnettler[9], or by measuring the intraoperative drainage volume, as in the study by Kizilkurt[10]. Changes in hemoglobin levels, length of stay, transfusion rate and drainage output are assessed similarly across the included studies.

Perioperative outcomes

This meta-analysis evaluates key perioperative outcomes across studies, focusing on blood loss, hospital stay, hemoglobin change, and transfusion rate.

Table 1. Characteristics of included studies

Author (Year)	**Design**	**Country**	**Inclusion**	**Exclusion**	**Number of Participant**				**Outcome**
					Torniquet	**TXA**	**Both**	**Control**	
Kukreja et al. (2022)	Retrospective	US	Patient underwent TKA	N/A	122	104	264	36	PL, BL, TIP
Kizilkurt et al. (2021)	Retrospective	Turkey	Patients diagnosed with primary end-stage knee osteoarthritis and primary TKA.	knee replacement surgery for secondary gonarthrosis (e.g., trauma, Paget disease, and rheumatological disease), valgus knee, patients with severe osteoporotic bone, patients with tibial defect which requiring screw or cement augmentation, unicondylar knee arthroplasty, patients using any anticoagulation before surgery (e.g., acetylsalicylic acid, phenprocoumon, warfarin, and low molecular weight heparin), revision knee arthroplasty reconstruction surgery, diagnosis of liver dysfunction/ coagulation dysfunction, patients with end-stage kidney disease, and a history of a peripheral arterial obstructive disease or thromboembolic events.	29	24	28	38	Pain, BL

Sah et al. (2022)	Prospe ctive	US	Subjects who underwent primary, unilateral, cemented, TKA advanced degenerative osteoarthritis and failed nonoperative treatment modalities prior to surgical reconstruction.	N/A	667 (group I: torniquet) 3582 (group II: bipolar sealer) 1599 (group III: bipolar sealer + TXA)				Hematocrit, transfusion rate
Schnettler et al. (2017)	Retros pective	US	patients who underwent primary total knee arthroplasty	history of deep venous thrombosis or pulmonary embolism, history of myocardial infarction or stroke within 6 months prior to the surgical procedure, history of renal dysfunction (glomerular filtration rate < 30 mL/min/1.73 m2), history of peripheral vascular disease, bilateral total knee arthroplasty, or body mass index (BMI) of >40 kg/m2	51	36	45	-	BL, transfusion rate, LOS

Huang et al. (2017)	RCT	China	patients 18 years of age or older who were scheduled for a primary total knee arthroplasty for end-stage osteoarthritis	Revision procedures, bilateral procedures, previous knee surgery, flexion deformity of ‡30_, varus-valgus deformity of ‡30_, anemia (hemoglobin [Hb] level of <12 g/dL for women and <13 g/dL for men), contraindications for the use of TXA (any history of blood clot events within 6 months), American Society of Anesthesiologists (ASA) grade IV, and coagulation disorder	50	50	50	-	PL, BL, transfusion rate, LOS

TXA, tranexamic acid; US, United States; TKA, total knee arthroplasty; PL, procedure length; BL, blood loss; TIP, total infusion pressor; LOS, length of stay.

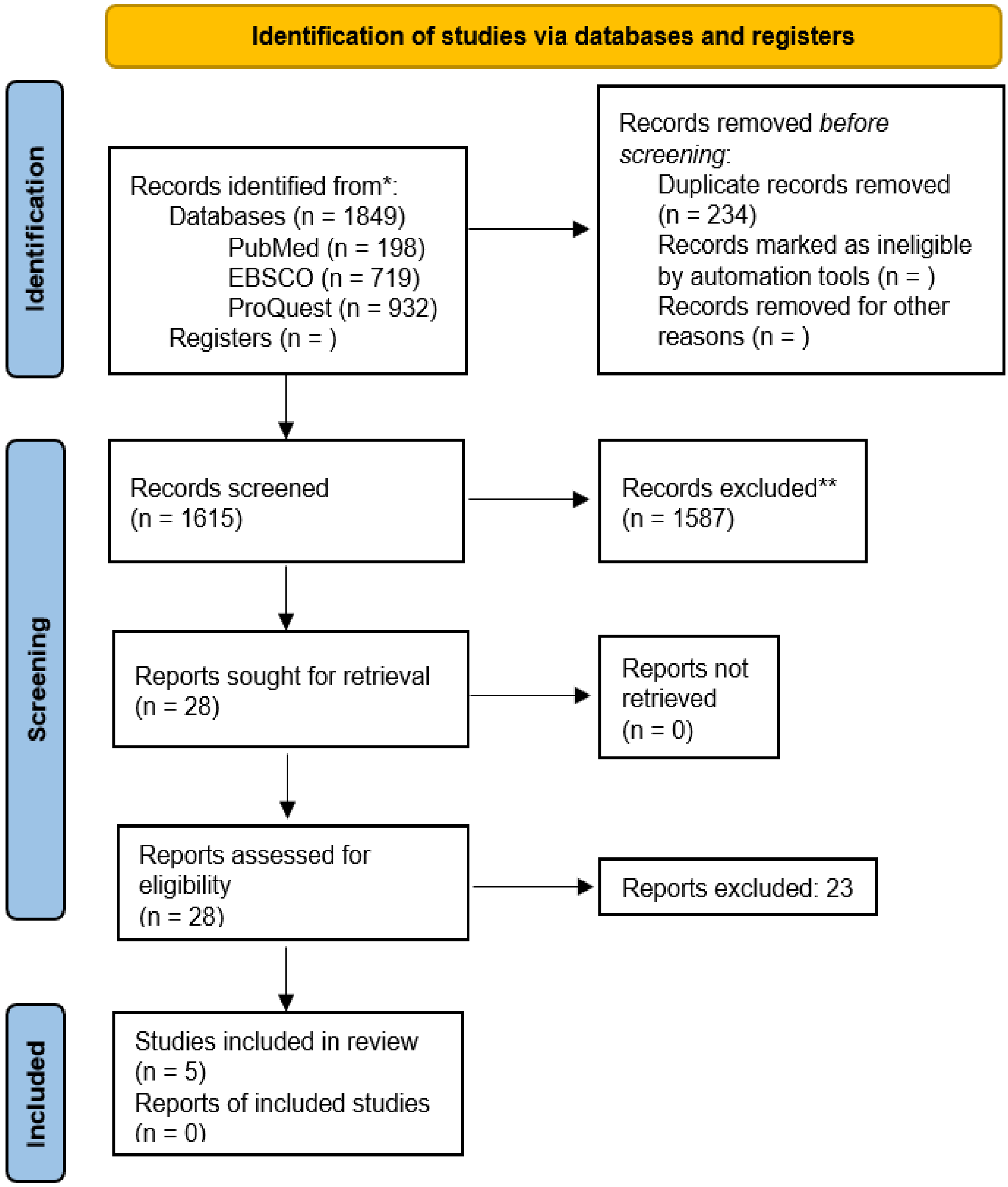

Figure 1. PRISMA Flow Diagram 2020

Blood Loss

The meta-analysis of perioperative blood loss (**Figure 2**) revealed a significant mean difference (MD) of 573.34 mL (95% CI: 123.68 to 683.23, p = 0.01), with high heterogeneity across studies (I^2 = 97%). This substantial blood loss occurs most often in tourniquet group, therefore favoring TXA group.

Length of Stay

The analysis of hospital length of stay (**Figure 3**) yielded a mean difference (MD) of 0.27 days (95% CI: -0.15 to 0.70, p = 0.20), with moderate heterogeneity (I² = 78%), hence there is no difference between TXA and touniquet impact in the length of stay. Although this result did not reach statistical significance, the moderate variability across studies suggests that factors other than the primary surgical procedures may influence hospital duration.

Hemoglobin Change

Hemoglobin changes were significant and favouring TXA group, with a mean difference (MD) of 1.47 g/dL (95% CI: 1.17 to 1.78, p < 0.01), demonstrating lower heterogeneity (I² = 42%) in this outcome (**Figure 4**). Hemoglobin changes were higher in touniquet group compared to TXA group.

Transfusion Rate

The analysis of transfusion rates (**Figure 5**) revealed a significant odds ratio (OR) of 7.52 (95% CI: 4.50 to 12.57, p < 0.01), with no heterogeneity across studies (I² = 0%) favouring TXA group. Patient in tourniquet only group experience higher transfusion rate compared to TXA group.

5. Discussion

The comparison between TXA and tourniquets in managing perioperative blood loss during surgical procedures, particularly TKA, has garnered significant attention in recent literature. Both interventions aim to reduce blood loss, minimize the need for transfusions, and ultimately improve patient outcomes, including hemoglobin levels, and length of hospital stay.

TXA is a synthetic antifibrinolytic agent widely recognized for its effectiveness in minimizing bleeding during surgical procedures and in trauma care. Its primary mechanism of action involves the inhibition of fibrinolysis, which is the process by which blood clots are broken down. TXA achieves this by competitively blocking the lysine binding sites on plasminogen, thereby preventing its conversion to plasmin, a key enzyme responsible for fibrin degradation.[11,12]

The meta-analysis findings on perioperative blood loss demonstrate a statistically significant mean difference of 573.34 mL between the study groups with lower changes in hemoglobin level in TXA group. Studies[2,13] indicate that TXA can decrease total blood loss by approximately 34% and reduce transfusion requirements by nearly 50% without increasing thromboembolic risks. A study[14] reported that the use of TXA effectively lowers the volume of blood transfusion from an average of 1.28 to 0.76 units. Conversely, the application of a tourniquet during surgery is traditionally believed to minimize intraoperative bleeding by providing a blood-free surgical field. However, recent findings[1,15] suggest that while tourniquets may reduce visible blood loss, they can lead to increased hidden blood loss and longer drainage output postoperatively. Furthermore, some studies[5,15] have reported no significant differences in hemoglobin levels between patients receiving TXA and those undergoing surgery with a tourniquet, indicating that the benefits of TXA may extend beyond mere blood loss reduction.

The analysis of transfusion rates indicated a notably high odds ratio favoring the TXA group, with a strong level of statistical significance. There was also an absence of heterogeneity across studies, which reinforces the consistency of this finding across different study populations and settings. Patients in the tourniquet-only group experienced markedly higher transfusion rates compared to those who received TXA, underscoring TXA's potential role in reducing the need for transfusions during surgery. TXA has consistently been associated with lower transfusion rates across multiple studies[16,17], with some reporting rates as low as 12.3% in patients receiving TXA compared to higher rates in those who did not. In contrast, the use of a tourniquet has been linked to a higher transfusion rate in certain cohorts, possibly due to the increased risk of postoperative complications such as hidden blood loss and prolonged recovery times[4,7]. A systematic review highlighted that the combination of TXA and tourniquet use did not significantly alter transfusion rates compared to TXA alone, suggesting that TXA may be sufficient for managing blood loss without the need for a tourniquet[4,6].

The length of hospital stay is another critical parameter influenced by the choice between TXA and tourniquet use. The analysis of both hospital length of stay and drainage output reveals no statistically significant differences between the TXA and tourniquet groups. The mean difference in hospital stay was minimal, and the moderate heterogeneity observed indicates that various factors beyond the primary interventions may contribute to the duration of hospitalization. Similarly, the drainage output analysis presented a substantial mean difference, albeit with high heterogeneity, further underscoring that variability in surgical methods and patient characteristics likely plays a role in drainage outcomes. However, some studies have indicated that patients who receive TXA tend to have shorter hospital stays compared to those who undergo surgery with a tourniquet, likely due to reduced complications and faster recovery times [4,7].

With this study, we aim to contribute insights and provide updates in the medical field to support more informed decision-making in blood loss control, especially in total knee arthroplasty procedures by comparing the use of tourniquet with tranexamic acid. Both modalities are relatively accessible, making them highly practical options. We acknowledge several limitations in this study, namely the high heterogeneity across the studies. Many factors that could still influence outcomes were uncontrolled in this research, such as tourniquet pressure, application time, and dosing regimens of tranexamic acid. These limitations underscore the need for further research with larger, more standardized studies that can comprehensively address these variables to better inform clinical practice in TKA.

As a conclusion, the use of tranexamic acid in TKA appears to offer significant advantages over tourniquet application in terms of reducing perioperative blood loss, lowering transfusion rates, and improving postoperative recovery metrics such as length of hospital stay. Although tourniquets remain useful in some cases, TXA's efficacy and safety suggest it may be a preferable choice in TKA procedures for optimizing blood management and patient recovery. Further standardized research is needed to refine best practices in TKA blood management.

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Figure 2. Forest plot of perioperative blood loss

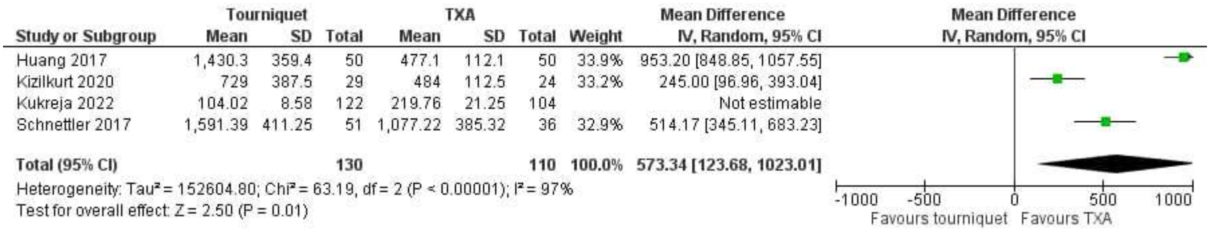


Figure 3. Forest plot of length of stay

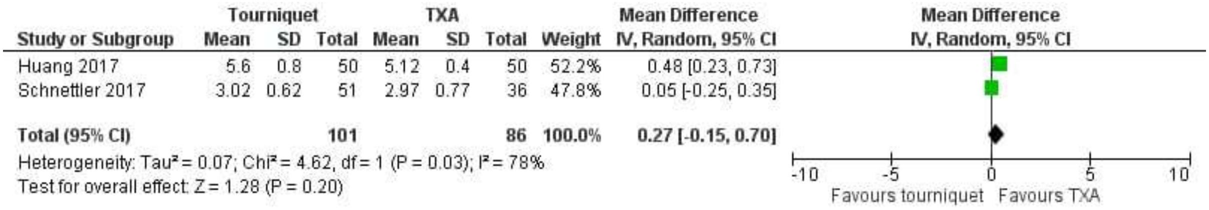


Figure 4. Forest plot of hemoglobin change

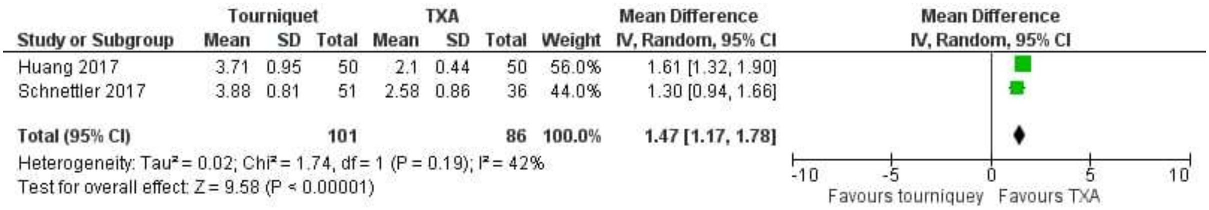
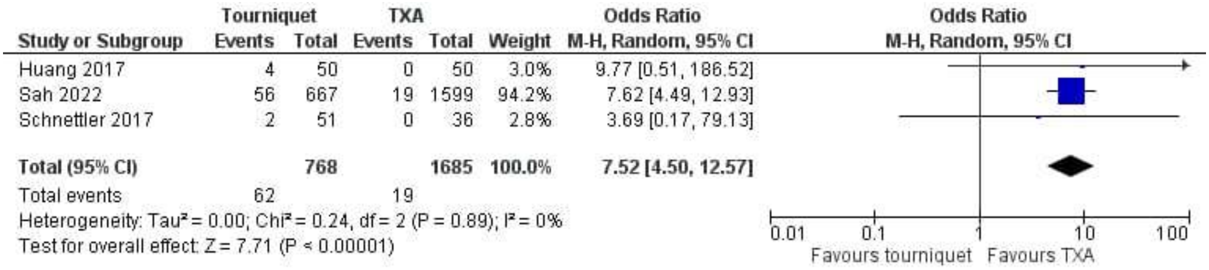


Figure 5. Forest plot of transfusion rate



Supplementary File 1. Risk of bias assessment

Randomized controlled trials (RoB 2)

No	Author, Year	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Overall
1	Huang et al.	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Cohort studies (JBI)

No	Author, Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Include
1	Schnettler et al., 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
2	Kukreja et al., 2022	Yes	Yes	Yes	No	No	Yes	Yes	Unclear	No	No	Yes	Yes
3	Sah et al., 2021	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Klzllkurt et al., 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Q1, Were the two groups similar and recruited from the same population?
Q2, Were the exposures measured similarly to assign people to both exposed and unexposed groups?
Q3, Was the exposure measured in a valid and reliable way?
Q4, Were confounding factors identified?
Q5, Were strategies to deal with confounding factors stated?
Q6, Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?
Q7, Were the outcomes measured in a valid and reliable way?
Q8, Was the follow up time reported and sufficient to be long enough for outcomes to occur?
Q9, Was follow up complete, and if not, were the reasons to loss to follow up described and explored?
Q10, Were strategies to address incomplete follow up utilized?
Q11, Was appropriate statistical analysis used?