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Original Article

The influence of knee position on blood loss and range of motion following total knee arthroplasty: a meta-analysis

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Abstract: A consistent post-operative limb positioning regime could be an attractive, simple and cost-effective alternative to improve patient's outcomes after total knee arthroplasty (TKA). The aim of this study was to perform a meta-analysis to determine the effect of postoperative knee position (flexion vs extension) on blood loss and range of motion (ROM) following TKA. A systematic search of all studies published through Dec 2015 was conducted using the MEDLINE, EMBASE, OVID, ScienceDirect and Cochrane CENTRAL databases. The relevant studies that examined whether post-operative limb positioning (flexion or extension) could effectively improve ROM restoration and reduce blood loss following TKA were identified. Demographic characteristics, blood loss and range of motion were manually extracted from all of the selected studies. Meta-analysis was conducted with the help of REVMAN software. Nine randomized controlled trials are eventually satisfied the eligibility criteria. Meta-analysis showed that post-operative knee flexion protocols could effectively reduce blood loss (SMD = -0.32, 95% CI: -0.59–0.05) and improve ROM (WMD = 4.47, 95% CI: 2.53-6.41) after TKA. No significant publication bias was showed by funnel plot. Based on the studies undertaken to date, a post-operative knee flexion protocol should be implemented as an easy and inexpensive method of reducing blood loss and increasing ROM following TKA. Further studies are still needed to confirm the present results.

Keywords: Total knee arthroplasty, post-operative, limb position, meta-analysis

Introduction

Total knee arthroplasty (TKA) is a very effective treatment for knee osteoarthritis (OA) and recent studies highlighted the increasingly growing use of TKA in the last decade [1-3]. It has the highest aggregate cost among the 2004-2007 top ten most rapidly increasing procedures in the USA [2]. TKA can effectively remove pain associated with joint activities and can recover the range of motion (ROM), which is closely related to the degree of satisfaction in patients [4]. The ultimate purpose of TKA is to restore the functional ROM to the minimum 90 degree that is required for normal daily activities. The early restoration of a satisfactory knee ROM can improve patient's discharge and a decreased transfusion rate could make the procedure cheaper.

Many factors affected ROM and several efforts have been made to improve functional recovery [5]. Different strategies have been recently implemented to reduce blood loss and increase ROM that are thought to be two important factors in determining the outcomes of TKA [6, 7]. Many of these strategies included the use of blood reinfusion systems [7], different drainages management protocols [8], antifibrinolytic medications [9] and etc. Among the these strategies, limb position in the immediate post-operative period could theoretically affects blood loss and ROM following TKA, and the reduction in transfusion requirement associated with ROM improvement could conversely reduce the overall costs [10, 11]. Particularly, it can be hypothesized that knee flexion can reduce bleeding because of the angulation of popliteal vessels, and the subsequent reduced hidden blood loss can improve ROM recovery [12].

A full extended position with compressive dressing applied to the knee has been traditionally proposed, notwithstanding various post-

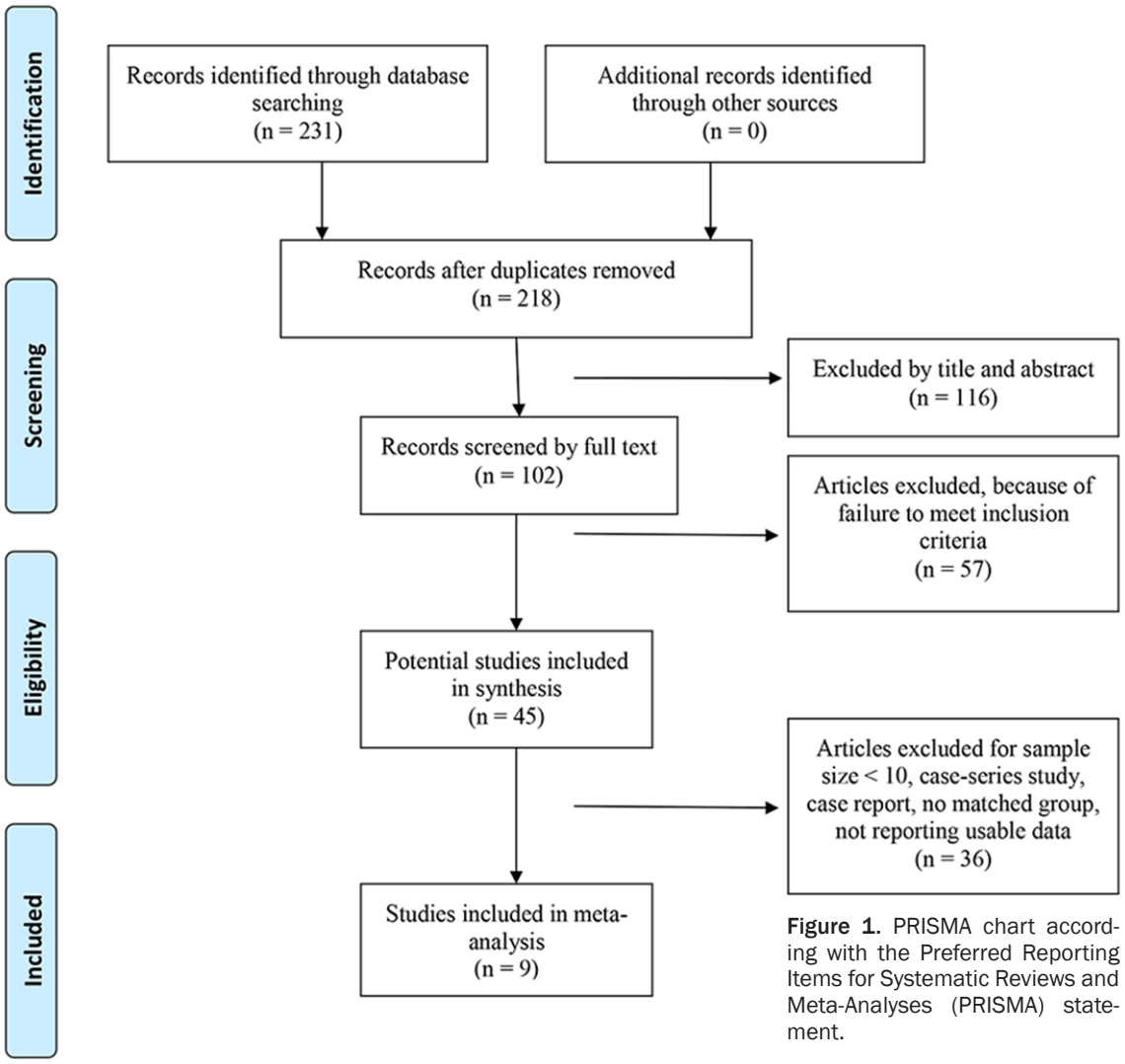

Figure 1. PRISMA chart according with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

operative limb positioning regimes could be ideally implemented. Although a post-operative limb positioning regime (flexion or extension) could be an attractive and simple method to improve patient's outcomes after TKA, the outcome of limb positioning management is still under debate [13].

At present, the data regarding the influence of knee position on blood loss and ROM following TKA are still conflicting. To the best of our knowledge, there was no meta-analysis conducted in this area. Therefore, the purpose of the present meta-analysis is to evaluate whether post-operative knee flexion protocol could effectively improve ROM restoration and reduce blood loss following TKA. The currently meta-analysis was conducted in order to provide synthesized evidence to this question.

Material and methods

Search strategy

To assemble all of the relevant published studies, PRISMA compliant searches of MEDLINE, EMBASE, Science Direct, OVID, the Cochrane CENTRAL database and Google scholar were performed for all peer-reviewed studies published through Dec 2015 that deal with post-operative limb positioning regimes after TKA. The following search terms were used to maximize the search specificity and sensitivity: total knee replacement, knee prosthesis, postoperative management, blood loss, range of motion, leg position, flexion, and extension.

Secondary searches of the unpublished literature were conducted by searching the WHO

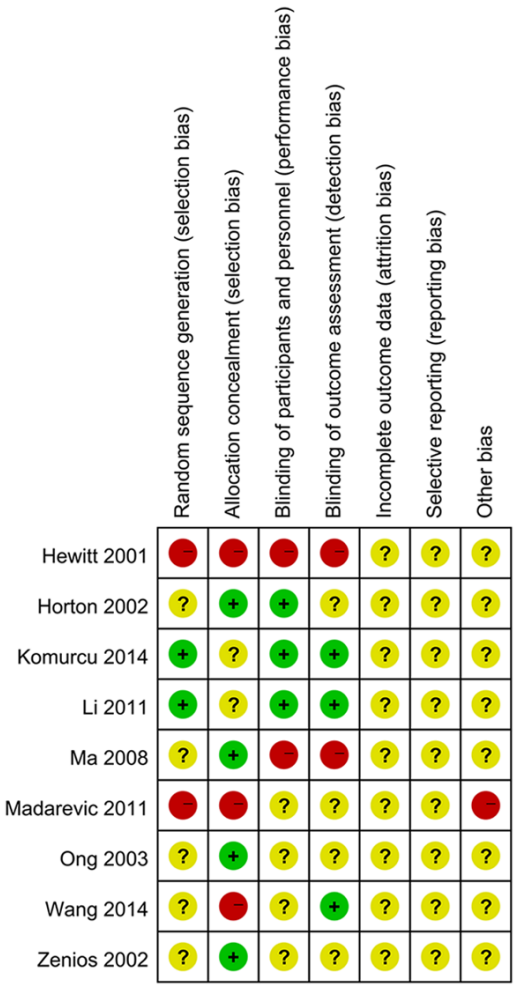

Figure 2. Methodological quality of included studies. This risk of bias tool incorporates assessment of randomization (sequence generation and allocation concealment), blinding (participants, personnel and outcome assessors), completeness of outcome data, selection of outcomes reported and other sources of bias. The items were scored with 'yes', 'no', 'unsure'.

International Clinical Trials Registry Platform, UK National Research Register Archive, and Current Controlled Trials from their inception to Dec 1, 2015. The reference lists of all the full text papers were examined to identify any initially omitted studies. All journals were considered, but only English papers were taken into account.

Inclusive and exclusive criteria

Only randomized controlled trials (RCTs) were included if they evaluated the effect of knee position during wound closure (flexed vs. extended) in TKA on blood loss and/or ROM. All patients were adults (>18 years of age) with OA or RA. There was no limit to type of knee prostheses, surgical technique and severity of diseases. Single case reports, reviews, biomechanical studies, in vitro reports and non-comparable studies were excluded.

Study selection

Two reviewers independently screened the titles and abstracts for the eligibility criteria. Subsequently, the full text of the studies that potentially met the inclusion criteria were read and the literature was reviewed to determine the final inclusion. We resolved disagreements by reaching a consensus through discussion.

Date extraction

Two of the authors independently extracted the following data from each full-text report using a standard data extraction form. The data extracted from studies included the title, authors, sample size, study design, blood loss, ROM and post-operative protocols. The corresponding authors of the included studies were contacted to obtain any required information that was missing. The extracted data were verified by a third author.

Outcomes

Blood loss and knee ROM after TKA were the outcomes of the present study.

Assessment of methodological quality

Following the Cochrane Handbook for Systematic Reviews of Interventions 5.0, the methodological quality of the RCTs was independently assessed by two authors. Any disagreements were resolved by discussion. A third author was the adjudicator when no consensus could be achieved.

Data synthesis and analysis

We performed all meta-analysis with the Review Manager software (RevMan Version 5.1; The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). For ROM, means and standard deviations were pooled to a weighted mean difference (WMD) and 95% confidence interval (CI) in the meta-analysis. As studies used a variety of continuous scales to evaluate blood loss, a unit-less measure of treatment effect size was needed to allow the results of various RCTs to be combined. Standardised mean differences (SMDs) of blood loss were used to calculate treatment

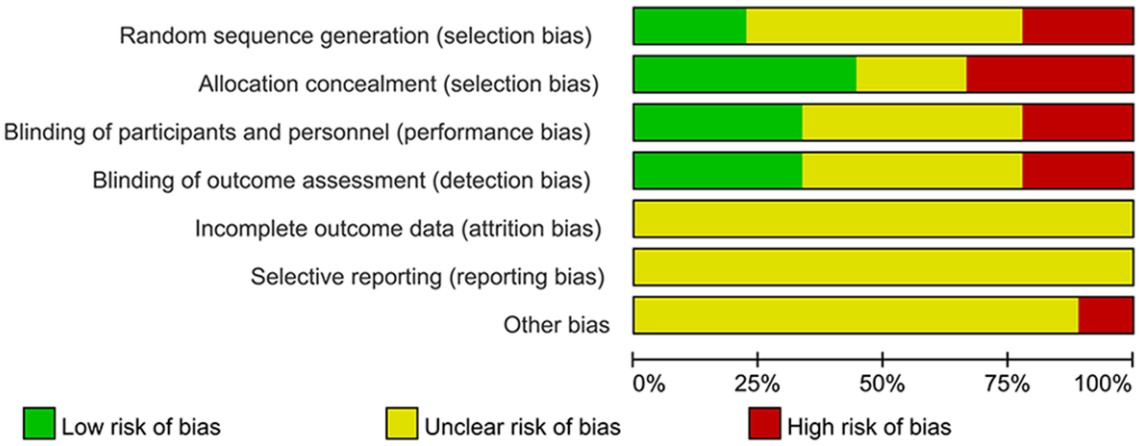

Figure 3. Risk of bias. Each risk of bias item presented as percentages across all included studies, which indicated the proportion of different level risk of bias for each item.

Table 1. Study characteristics of included studies

Studies	Design	Country	Publication year	Sample size		Mean age (years)		Gender (m/f)		Conflicts of interest
				F	E	F	E	F	E	
Wang et al.	RCT	China	2014	40	40	68.34±7.09	67.87±6.47	7/33	9/31	No
Komurcu et al.	RCT	Turkey	2014	14	15	66.1±4.8	67.8±5.6	10/4	12/3	No
Li et al.	RCT	China	2011	55	55	71±6	70±8	15/40	17/38	No
Hewitt et al.	RCT	UK	2001	86	74	73.4	71.7	41/45	33/41	No
Horton et al.	RCT	UK	2002	27	28	66.0±13.5	66.01±10.0	11/16	15/13	Yes
Ma et al.	RCT	Australia	2008	49	46	71.0±9.39	70.6±8.5	24/25	24/22	No
Madarevic et al.	RCT	Croatia	2011	16	47	70±7		19/44		No
Ong et al.	RCT	UK	2003	20	20	71	74	8/12	7/13	Yes
Zenios et al.	RCT	UK	2002	39	42	71.0±7.8	71.3±6.9	13/26	13/29	No

RCT, Randomized controlled trials, F, Flexion group, E, Extension group.

effect sizes in the mate-analysis. Inverse-Variance analysis method was used to combine the statistics. A probability of $P<0.05$ was regarded as statistically significant. The assessment for statistics heterogeneity was calculated through chi-square and I-square test. I-square <20% implied low statistics heterogeneity, a fixed effect model was used. A random effect model was used when I-square >20%. Publication bias was assessed by funnel plot.

Results

Search results

A total of 218 titles and abstracts were preliminarily reviewed, of which 9 studies [14-22] eventually satisfied the eligibility criteria (**Figure 1**). 713 patients were included in the 9 studies, 346 in the flexion group and 367 in the extension group.

Quality assessment

Among the 9 included studies, 5 RCTs [15, 16, 18, 21, 22] had a low risk of bias, and other 4 RCTs [14, 17, 19, 20] had a high risk of bias. Two RCTs [15, 16] reported specific methods for adequent generation of allocation sequence, and four trials [18, 19, 21, 22] reported allocation concealment. Whilst surgeon blinding would have been inappropriate in this study design, 6 studies [15, 16, 18, 20-22] did not report the blindness of their assessors to patients group. Only two trials [15, 16] performed the double-blinding to assessors and participants. All studies reported that they received no grant in support of their research. The methodological quality of included studies was presented in **Figure 2**. Judgements about each risk of bias item presented as percentages across all included studies in **Figure 3**.

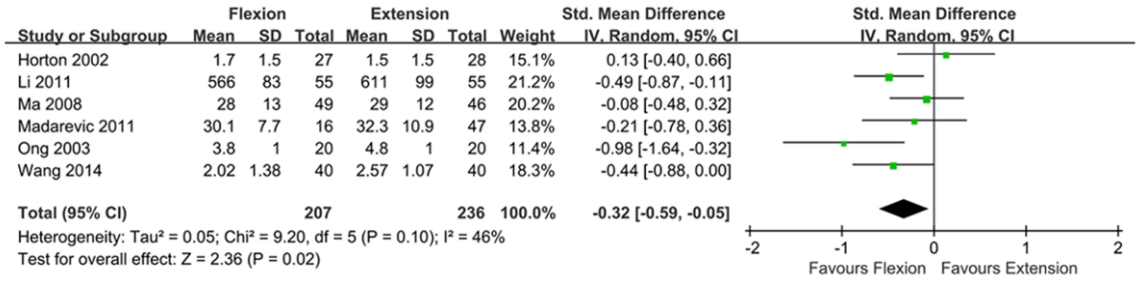

Figure 4. Standardized mean difference (SMD) estimate for blood loss.

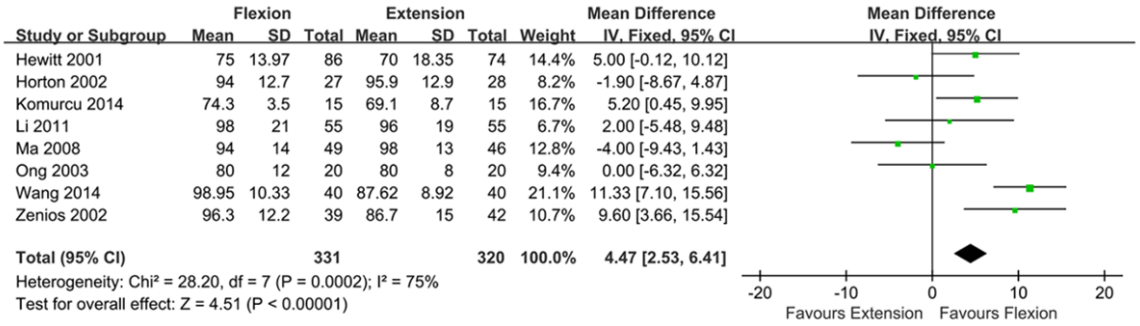

Figure 5. Weighted mean difference (WMD) estimate for range of motion (ROM).

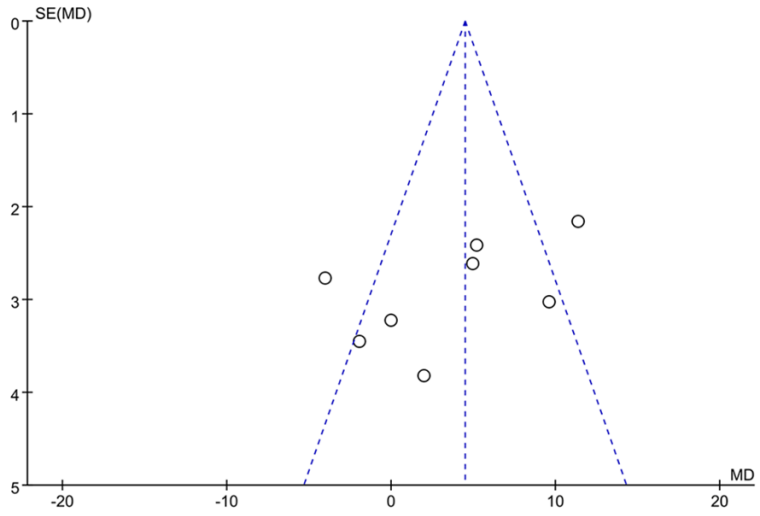

Figure 6. Funnel plot to assess publication for the most frequently reported outcome-ROM.

Demographic characteristics

The demographic characteristics of studies included is summarised in **Table 1**. Nine RCTs involving 713 patients were eligible for inclusion, with individual sample size ranging from 29 to 160 patients. Limb position was flexion in 346 patients after TKA, while limb position was extension in 367 patients. All studies stated the gender of their cohorts. All patients had been treated with primary TKA for OA or RA. The same standardized surgical technique was applied in eight studies [14-18, 20-22]. The operations were performed by a single surgeon in two papers [14, 17] and by different surgeons in four papers [16, 18, 19, 21]; no indications regarding the operating surgeons were supplied in the remaining three papers [15, 20, 22]. There were 4 studies undertaken in UK, 2 in China, 1 respectively in Croatia, Turkey, and Australia. All the included studies had definite inclusion/exclusion criteria.

Results of meta-analysis

In 6 studies [14, 16, 18-21] providing blood loss between flexion and extension groups, the pooled SMD was -0.32 (95% CI: -0.59--0.05).

There was significant difference between the both groups (**Figure 4**). The available data demonstrated that blood loss was significantly reduced in flexion groups compared with extension groups. Regarding ROM after TKA reported in 8 studies [14-19, 21], limb position in flexion was superior to in extension (WMD = 4.47 95% CI: 2.53-6.41) (**Figure 5**).

Publication bias

The publication bias test was performed by ROM. No significant publication bias was showed by funnel plot (**Figure 6**).

Discussion

TKA gained increasing popularity over recent years, and both the annual rate of procedures and the overall costs are expected to grow over the next decades [23, 24]. In order to reduce the burden on national health-care resources, many attempts have been made to improve functional results, whose are strongly influenced by blood loss reduction and ROM restoration [25]. Therefore, more attention have been placed on the above two factors. Although the development of a strategy of post-operative limb management could be a simple and inexpensive way to maximize the cost-effectiveness of TKA, the results are still in controversy. The purpose of the present study was to ascertain whether post-operative limb positioning (flexion or extension) could effectively improve ROM restoration and reduce blood loss following TKA.

Meta-analysis is used as the main method in the research paper. It is more accurate and reliable than regression analysis or original papers. Meta-analysis can enhance statistical power and enlarger sample size by combining original studies, which could provide more robust evidence. Therefore, we conducted a meta-analysis to evaluate the evidence from relevant studies that examine whether post-operative limb positioning (flexion or extension) could effectively improve ROM restoration and reduce blood loss following TKA. Furthermore, there have been no guidelines or recommendations for limb position after TKA. Therefore, there is a need for an evidence base to help surgeons make clinical decisions and develop optimal limb position after TKA. To the best of our knowledge, this study is the first meta-analysis to evaluate the quality of the evidence investigating the influence of limb position (flexion or extension) on blood loss and ROM after TKA.

The most important finding of the present meta-analysis is that post-operative knee flexion protocols could effectively reduce blood loss and improve ROM after TKA. However, the methodological quality assessment identified a number of limitations to the current evidence base. In many studies, the sample size of the comparative groups was small. Although 7 of studies included reported the randomization, 5 did not describe the specific methods of randomization. Thus, we had no enough information to determine whether to use the exact randomized methods. Only 4 had reported concealment of randomization, allowing selection and allocation bias. Furthermore, no blinding of patients and assessors to their surgical procedure in several studies permitted further measurement and expectation bias and potential for type II statistical error of these clinical outcomes. All studies included had the consistent baseline, nevertheless no intention to analysis (ITT) was performed for withdraws and dropouts. In addition, clinical heterogeneity to a certain degree was induced by different limb position regimes and measurement of blood loss and ROM. Accordingly, whilst the results of the meta-analysis should be considered as appropriate, these methodological quality defects should be considered when doing interpretation of the findings.

Some degree of clinical heterogeneity was induced by the different surgical technologies used, surgical approach, medical co-morbidities, post-operative limb position regimes, severity of diseases, surgical duration, pre-surgical medical status, follow-up times, surgeon's experience, and use of drains. Heterogeneity may have also been caused by poor study design. Because of limited information got from original studies, heterogeneity cannot be completely resolved. Accordingly, although the results of the meta-analysis should be considered appropriate, methodological quality defects and clinical heterogeneity should be considered when interpreting the findings.

Vessels angulation due to different degrees of knee flexion and the increased local tension due to the decreased venus return could

explain the reduced bleeding. The decreased swelling and hidden blood loss in turns facilitate ROM restoration by reducing intraarticular pressure and capsular tension. Knee stability are the primary goals of TKA. Good ROM improves function after TKA. Therefore, postoperative knee flexion protocol may be a useful rehabilitation technique.

The limitations of this meta-analysis mainly include the following items: (1) efficacy of statistics may be further improved by including more multi-centers studies with more sample size in the future; (2) Owing to the finite of included studies, subgroup analysis cannot be performed on every sources of heterogeneity. It may exert instability on consistency of outcomes. (3) Long-term follow-up results may change the current conclusions.

Conclusion

Based on the current evidence, post-operative knee flexion protocols could effectively reduce blood loss and improve ROM after TKA. Therefore, a post-operative knee flexion protocol should be implemented as an easy and inexpensive method of reducing blood loss and increasing ROM following TKA. Further high-quality studies are still required in the future.

Disclosure of conflict of interest

None.

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