European Review for Medical and Pharmacological Sciences 2023; 27: 5059-5069

Lateral retraction could achieve better early postoperative knee function than patellar eversion in total knee arthroplasty: a systematic review and meta-analysis

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Abstract. – OBJECTIVE: Comparisons between patellar eversion (PE) and lateral retraction (LR) in total knee arthroplasty (TKA) are still inconclusive. To determine the most suitable procedure, we aimed to evaluate the safety and efficacy of PE and LR in TKA in this meta-analysis.

MATERIALS AND METHODS: This meta-analysis complied with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Web-based literature databases, including WANFANG, VIP, CNKI, the Cochrane Library, Embase, and PubMed, were utilized to conduct a comprehensive literature search for studies published until June 2022 that compared PE with LR in primary TKA. The quality of the selected randomized controlled trials (RCTs) was evaluated using guidelines of the Cochrane Reviews Handbook 5.0.2.

RESULTS: A total of 10 RCTs, including 782 patients and 823 TKAs, were selected in this meta-analysis. Our results showed that using LR improved postoperative knee extensor function and range of motion (ROM). In addition, PE and LR resulted in similar clinical benefits in terms of Knee Society Function score, pain, length of hospital stay, Insall-Salvati ratio, the occurrence of patella baja, and complications related to the operation.

CONCLUSIONS: Existing evidence suggested that using LR in TKA improved early postoperative knee function. Similar clinical and radiographic outcomes were obtained 1 year after the procedures were performed. Based on these findings, we recommended the use of LR in TKA. However, studies with large sample sizes are needed to validate these findings.

Key Words:
Total knee arthroplasty, Patellar eversion, Lateral retraction, Meta-analysis.

Introduction

Total knee arthroplasty (TKA) is an established procedure to restore normal joint function and correct deformities in degenerative knee disease[1-3]. Patellar eversion (PE) (Figure 1A) in TKA offers adequate surgical exposure to the joint, while there is a risk of the quadriceps tendon splitting, delaying the restoration of quadriceps function[4]. Therefore, lateral retraction (LR) (Figure 1B) has been proposed in TKA to reduce detrimental effects caused to the extensor mechanism. Some studies[5-9] have reported that LR provides the advantages of more rapid functional recovery, improvement in knee range of motion, reduced duration of hospital stay, and relief of pain. In contrast, several other investigations[10,11] have shown that PE does not adversely affect quadriceps recovery following TKA.

Furthermore, two meta-analyses[12,13] have revealed that both these procedures do not significantly affect post-TKA outcomes. In contrast, one meta-analysis[14] has shown that patellar non-eversion in primary TKA results in lower rates of complications. Given the inconsistencies in the findings across several studies, it is necessary to conduct a systematic meta-analysis to objectively assess the effectiveness and safety of PE and LR in TKA to guide surgeons in clinical decision-making.

Materials and Methods

Search Methods

A comprehensive literature search was conducted to compare the outcome of PE and LR in

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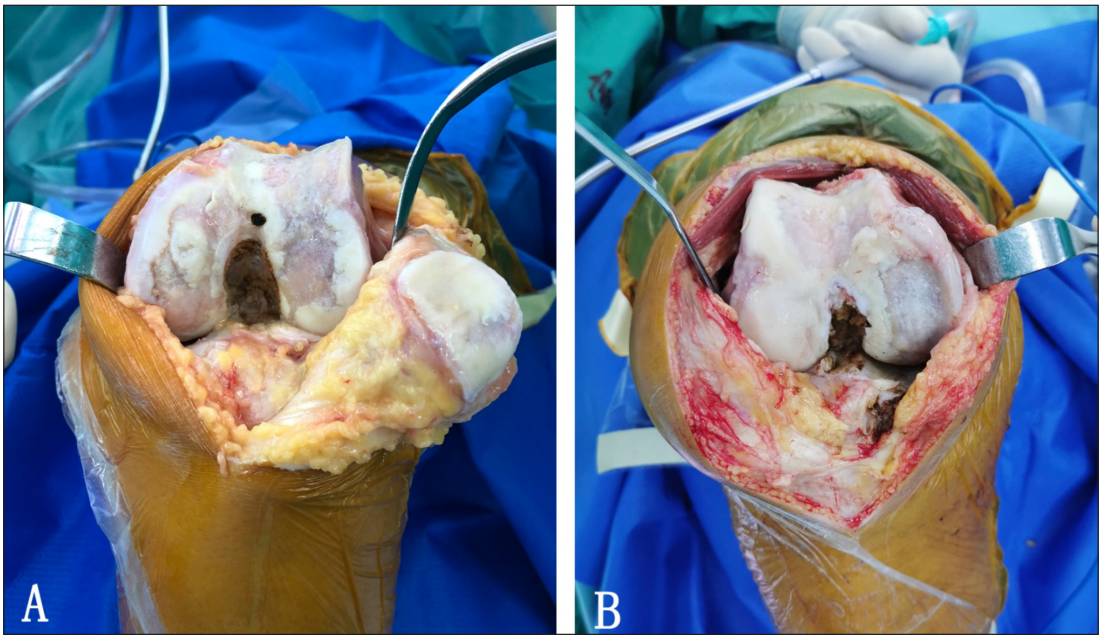

Figure 1. Schematic diagram of PE (**A**) and LR (**B**).

primary TKA using several web-based literature databases, including WANFANG, VIP, CNKI, the Cochrane Library, Embase, and PubMed. All literature available until June 2022 was extracted. The search terms used were "TKA" or "TKR" or "total knee arthroplasty" or "total knee replacement", "eversion" and "retraction". The search was limited to full-text publications on patients. A manual search for relevant reviews, trials, and articles was also performed to ensure that no articles were missed.

Inclusion Criteria

The inclusion criteria were all randomized controlled trials (RCTs) that compared the outcomes of LR and PE during primary TKA. In addition, if more than one publication was available on a specific trial, the most recent publication with the highest data quality was selected. The exclusion criteria were quasi- or non-randomized trials and studies conducted on participants with severe knee deformity (varus or valgus ≥15°), hemophilia-associated arthritis, previous knee surgery, and reflections on TKA revision.

Outcomes of Interest

The primary outcome for this meta-analysis was postoperative knee extensor function, which was described using two indicators: days taken until straight leg raising (SLR) was achieved and postoperative quadriceps strength. The secondary outcomes were improved knee function [determined using the Knee Society function score and knee range of motion (ROM)], pain [determined using the visual analog scale (VAS) and Knee Society pain score], length of hospital stay, tourniquet time, Insall-Salvati ratio, the occurrence of patella baja, and complications related to the operation.

Data Extraction

Two reviewers independently extracted the following data from each study: publication date, authors, country, number of patients and knees, body mass index (BMI), age, gender percentage, diagnosis, approach, indicators, type of prosthesis, patellar resurfacing, surgical approach, and the use of cement in both the PE and LR groups. In the case of disagreement, a consensus was achieved through a discussion with a senior reviewer.

Assessment of Methodological Quality

The methodological quality of the studies was independently assessed by both reviewers using the Cochrane Reviews Handbook 5.0.2[15]. In addition, the studies were evaluated using the following criteria: selective reporting, incomplete

outcome data, blinding of outcome assessments, allocation concealment, random sequence generation, and other biases. Any disagreements between the two reviewers were mediated by an independent arbiter.

Statistical Analysis

Our meta-analysis ("Experimental" = "PE" and "Control" = "LR") was carried out using the Cochrane Collaboration software package, RevMan 5.2 (Review Manager Web, The Cochrane collaboration, Copenhagen, Denmark). The risk ratio (RR) was calculated with a 95% confidence interval (CI) for dichotomous outcomes, while continuous outcomes were assessed *via* weighted mean differences (WMD) with a 95% CI. A p-value <0.05 was considered statistically significant for both RR and WMD. The I^2 value and the Chi-squared test were used to assess statistical heterogeneity. The absence of heterogeneity was determined using a threshold of p-value >0.1 and an I^2 value of ≤50%. The overall summary of effect sizes was estimated using a fixed-effects model or a random-effects model.

Results

Characteristics of Selected Studies

The flow chart of the study selection process was presented using Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2009 Flow Diagram (Figure 2). A total of 10 RCTs[6-12,16-18] comparing the outcomes of PE and LR in TKA were identified, including 782 patients and 823 knees, with 40 to 200 participants in each RCT. All included studies were published between 2007 and 2021. It was worth noting that the baseline BMI was not compared in four trials[9,17-19], which might induce potential bias. Table I provides further details on each RCT.

The Risk of Bias in the Selected Studies

As per Cochrane Collaboration-based guidelines, the general methodological quality of the selected RCTs was found to have a low risk of bias. Figure 3 presents further information on the risk of bias in the methodological quality of the studies.

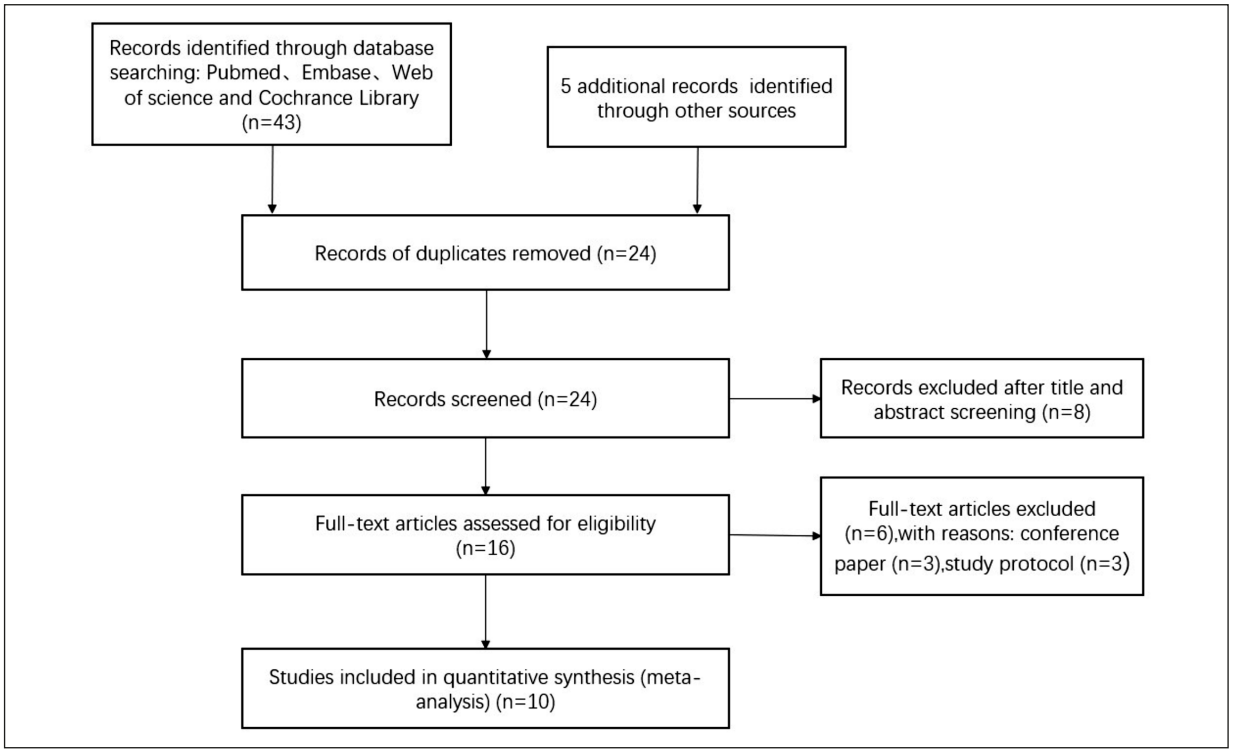

Figure 2. Flow chart of meta-analysis.

Table I. Characteristics of included studies.

Reference and year	Country	No. of patients			No. of knees		Female		Age (mean)		BMI		Diagnosis	Approach		Type of prosthesis	Patella resurfacing	Use of cement
		Total	PE	LR	PE	LR	PE	LR	PE	LR	PE	LR		PE	LR			
Walter et al[6] 2007	USA	61	36	25	36	25	26	19	75.7	71.5	31.3	31.8	NA	Midvastus	Midvastus	CR or PS prosthesis	NA	NA
Dalury et al[16] 2009	USA	37	37	37	37	37	22	22	65.7	65.7	31.6	31.6	Osteoarthritis	Medial parapatellar	Medial parapatellar	CR prosthesis	NA	Yes
Arnout et al[7] 2009	Belgium	60	30	30	30	30	18	22	67	64	28.2	31	Osteoarthritis	Medial parapatellar	Medial parapatellar	NA	Yes	Yes
Majima et al[17] 2011	Japan	180	NA	NA	100	100	82	79	69.2	71.8	NA	NA	Osteoarthritis	Subvastus	Subvastus	PS prosthesis	Yes	Yes
Umrani et al[10] 2013	Korea	72	36	36	36	36	36	36	66.7	64.3	27.63	28.78	Osteoarthritis	Midvastus	Midvastus	CR or PS prosthesis	Yes	Yes
Reid et al[18] 2014	Australia	66	36	30	36	30	20	18	68	70	NA	NA	NA	Medial parapatellar approach	Medial parapatellar approach	CR prosthesis	No	Yes
Jenkins et al[11] 2014	USA	117	57	60	57	60	38	35	60	60	31.3	32.4	Osteoarthritis	Medial parapatellar approach	Medial parapatellar approach	PS prosthesis	Yes	NA
Zan et al[19] 2016	China	44	44	44	44	44	18	26	NA	NA	NA	NA	Osteoarthritis	Medial parapatellar approach	Medial parapatellar approach	CR prosthesis	No	Yes
Yuan et al[8] 2020	China	104	52	52	52	52	30	32	65.9	67.2	26.5	26.8	Osteoarthritis	Medial parapatellar approach	Medial parapatellar approach	NA	No	NA
Chowdhury et al[9] 2021	India	41	41	41	41	41	31	31	NA	NA	NA	NA	Osteoarthritis	Medial parapatellar	Medial parapatellar	CR prosthesis	No	Yes

PE: patellar eversion, LR: lateral retraction, BMI: body mass index, NA: indicates not available, CR: posterior cruciate retaining, PS: posterior cruciate substituting.

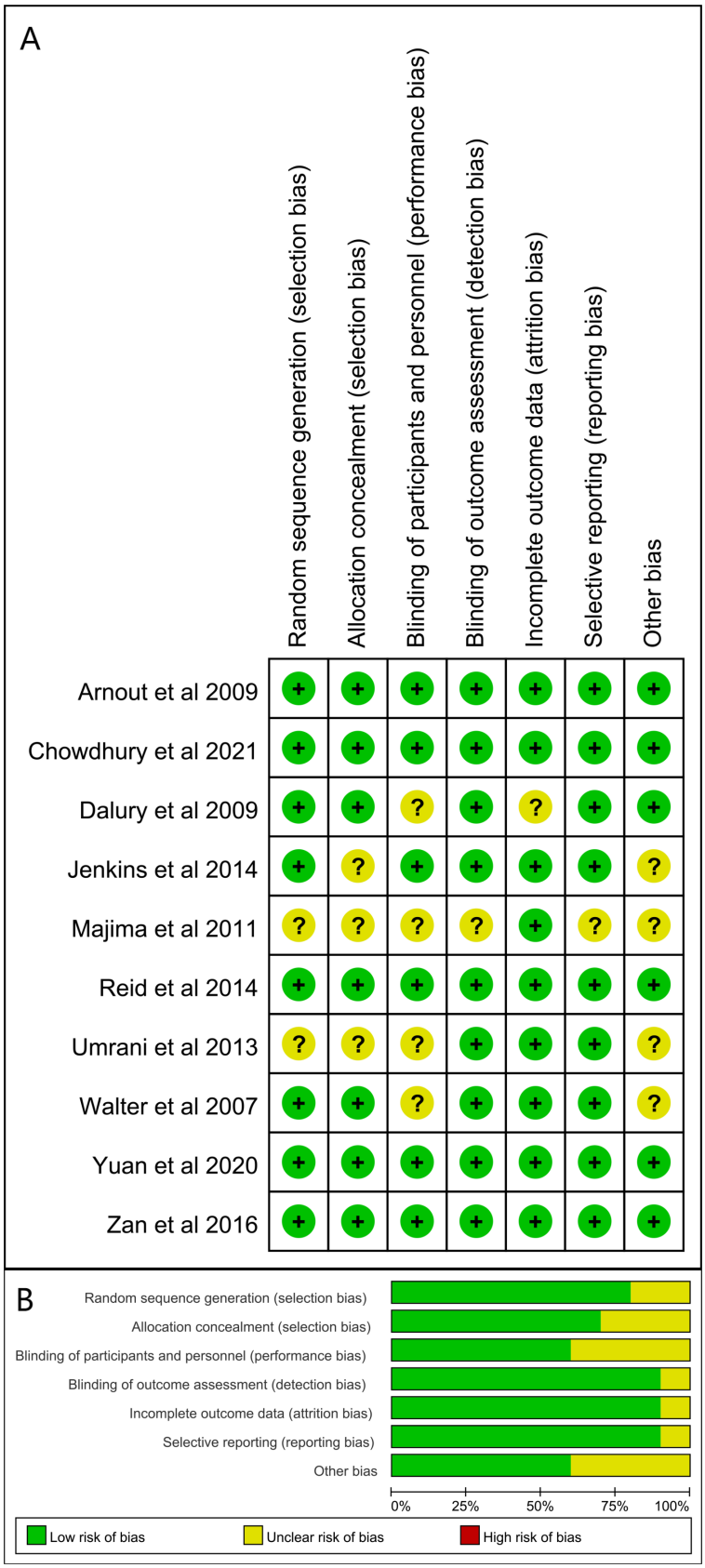

Figure 3. Risk of bias summary.

Meta-Analysis Results

Postoperative knee extensor function

SLR and postoperative quadriceps strength were adopted as the primary outcomes to evaluate postoperative knee extensor function. Five studies[6,8,9,17,19] on 535 knees achieved SLR ability during the postoperative period. A pooled analysis showed that LR required a shorter duration to achieve SLR (WMD=0.56, 95% CI, 0.30, 0.83; $p<0.0001$; random-effects model) (Figure 4). However, pooled results were difficult to achieve as various outcome parameters were used to assess postoperative quadriceps strength. Therefore, a descriptive analysis was carried out, and those who underwent LR tended to gain better postoperative quadriceps strength.

Improvement in knee function

Three RCTs[7,9,16] on 216 knees reported knee function using the Knee Society Function score. The results showed that PE produced a similar Knee Society Function score (WMD=-2.82, 95% CI, -9.18, 3.54; $p=0.38$; random-effects model). However, the pooled results demonstrated that LR achieved a bigger ROM than PE at 1 year (WMD=-3.04, 95% CI, -5.52, -0.57; $p=0.02$; random-effects model), while both groups were not significantly different (WMD=-1.36, 95% CI, -5.22, 2.49; $p=0.49$; random-effects model) at 6 months (Figure 5).

Pain (VAS and Knee Society pain score)

Six studies[6,8,9,11,12,18] on 518 knees included pain scores in terms of visual analogue scale (VAS). Our pooled results showed that the VAS pain scores were similar between PE and LR (WMD=0.06, 95% CI, -0.05, 0.17; $p=0.29$; fixed-effects model). In addition, no significant difference was found in Knee Society pain score between the two groups (WMD=-0.49, 95% CI, -3.62, 2.64; $p=0.76$; fixed-effects model) (Figure 6).

Meta-Analysis of Other Factors

Six studies[7,8,10,11,17,19] on 641 knees reported tourniquet time, and the WMD was -7.02 (95% CI, -6.20, -1.81; $p=0.0004$; fixed-effects model), indicating that tourniquet time in PE was shorter than in LR (Figure 7A). However, our pooled results showed no significant difference between PE and LR in the length of hospital stay (WMD=0.71, 95% CI, -0.12, 1.54; $p=0.09$; random-effects model) (Figure 7B), the occurrence of patella baja (RR=0.99, 95% CI, 0.31, 3.15; $p=0.99$; fixed-effects model) (Figure 7C), Insall-Salvati ratio (WMD=-0.04, 95% CI, -0.17, 0.09; $p=0.52$; random-effects model) (Figure 7D), and operation complications (RR=1.28, 95% CI, 0.77, 2.12; $p=0.34$; fixed-effects model) (Figure 7E).

Discussion

Several surgeons have utilized PE in TKA to achieve an improved surgical field of the lateral aspects of the tibia, leading to a quicker and increasingly precise operation. However, the use of PE in TKA still remains controversial. Some surgeons[9,20,21] believe that PE exerts excessive stress and tension on the extensor mechanism, which may weaken the quadriceps muscle, leading to poorer postoperative rehabilitation outcomes. A systemic review and meta-analysis[12] conducted on six RCTs, including 414 patients, has shown that PE results in a shorter surgery time but a longer skin incision. No significant differences are found

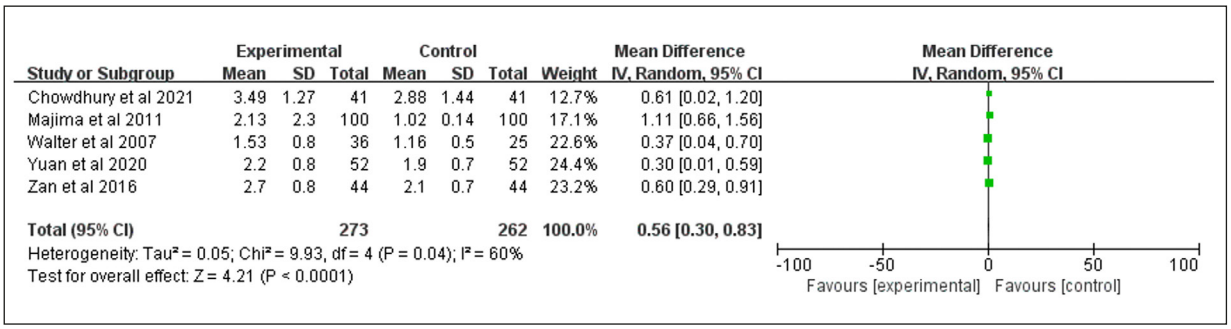

Figure 4. Forest plot of SLR in the two groups.

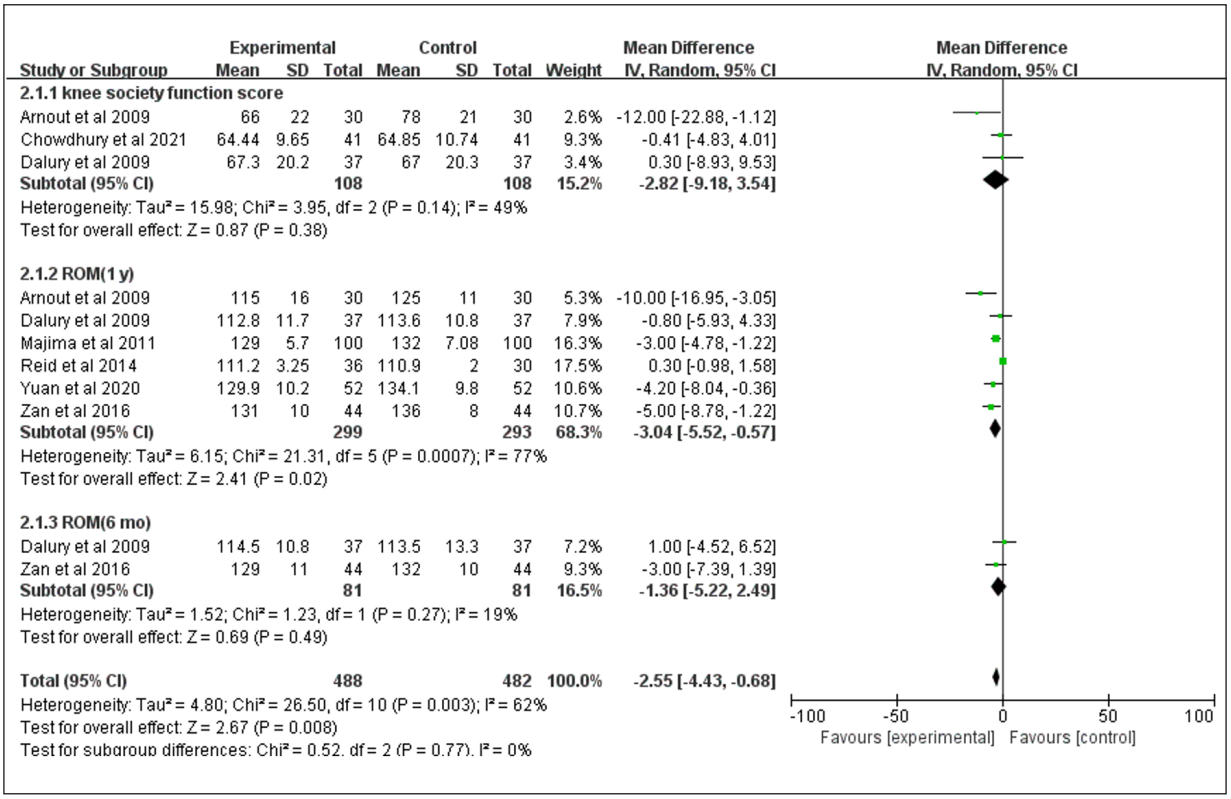

Figure 5. Forest plot of knee society function score and ROM in the two groups.

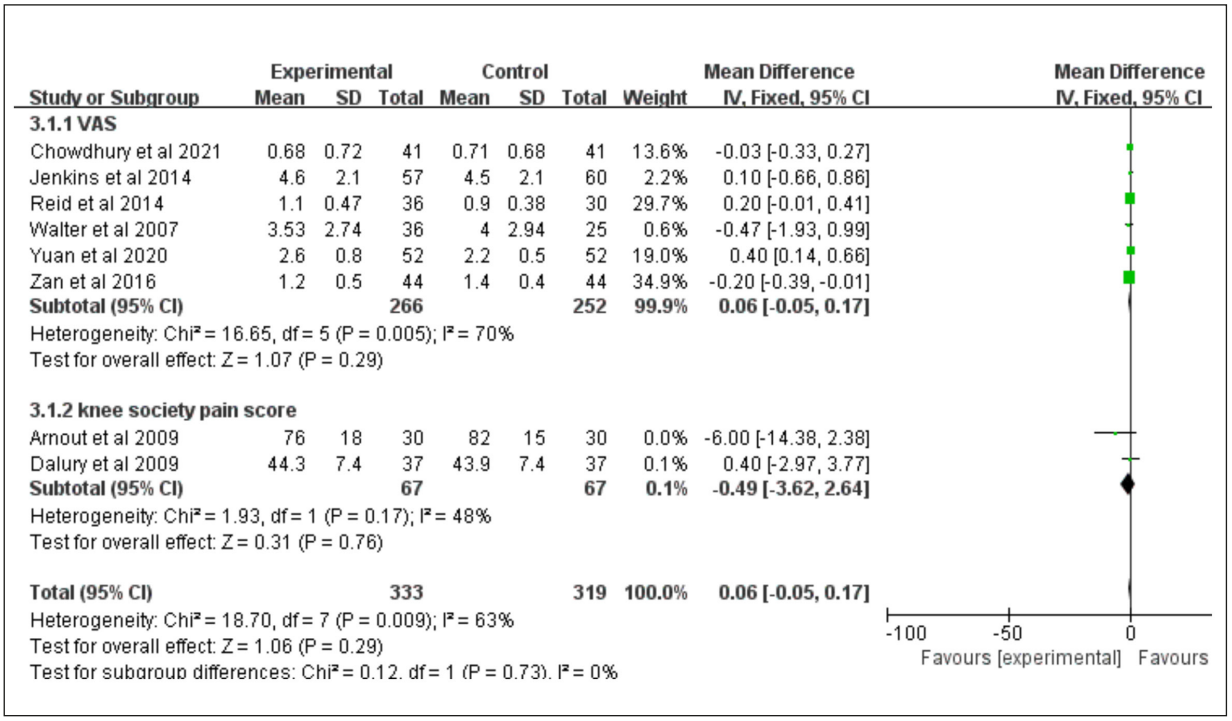

Figure 6. Forest plot of VAS and knee society pain score in the two groups.

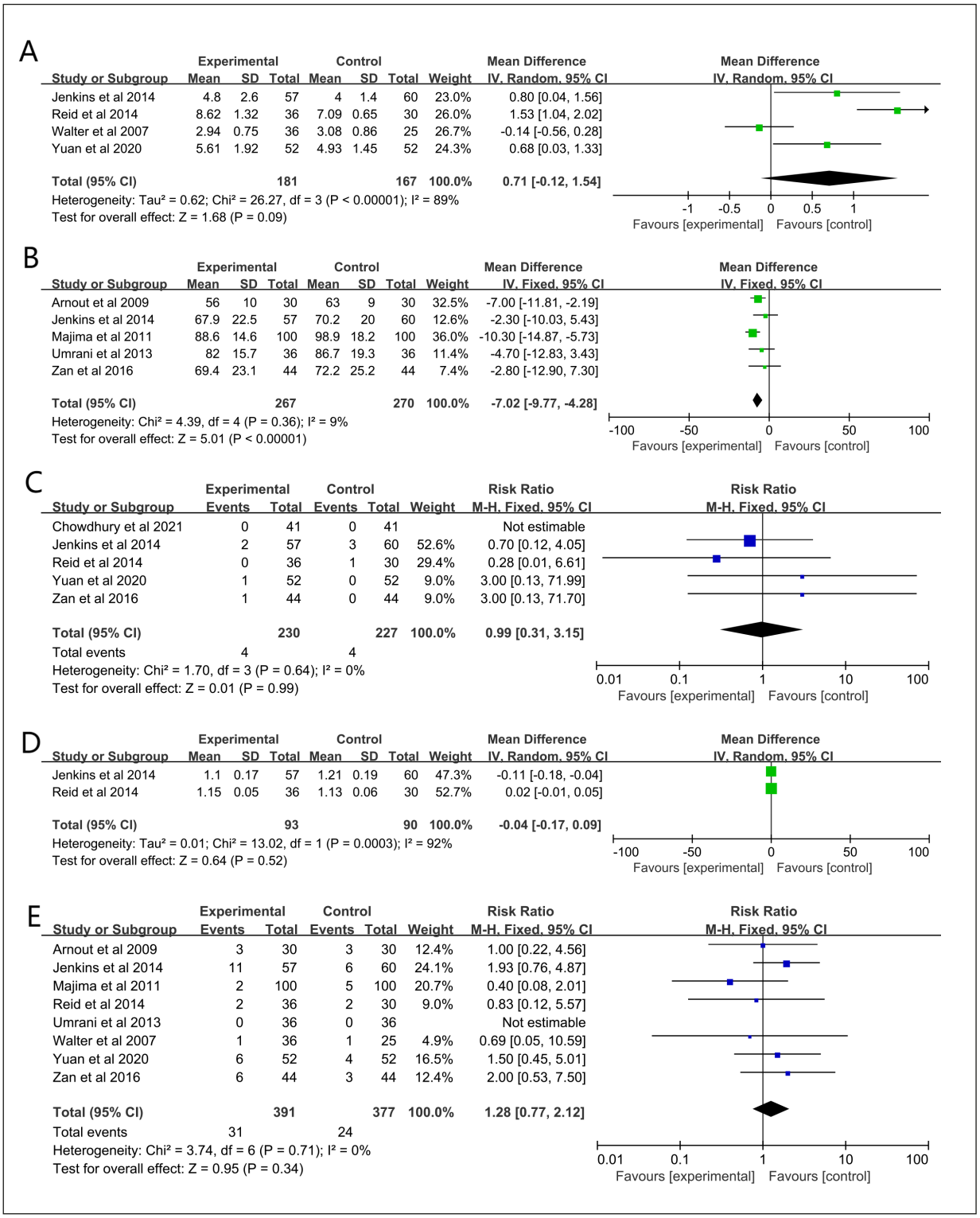

Figure 7. Forest plot of other factors in the two groups.

in quadriceps strength, complications, SLR, VAS, and functional scores. Jia et al[13] have revealed no significant differences in quadriceps strength, quality of life, pain, functional scores, patellar alignment and height, or complication rates between PE and LR. Yang et al[14] have demonstrated that the patellar non-eversion approach results in lower postoperative complications and a shorter

hospitalization duration but a longer surgery duration. Therefore, it remains inconclusive whether LR or PE is more advantageous in TKA.

Given the lack of a consensus in the currently available literature, we aimed to compare clinical and radiological outcomes between PE and LR. In our present meta-analysis, postoperative knee extensor function, a clinically meaningful outcome assessed *via* SLR and postoperative quadriceps strength, was used as the primary indicator. It is a core concern of orthopedic surgeons. Theoretically, PE may impair the integrity of the femoral quadriceps tendon, reducing the strength of the quadriceps muscle. The results of our meta-analysis appeared to support this theory. As for SLR, the pooled results showed that LR required a shorter duration to achieve SLR. Moreover, a descriptive analysis was conducted due to the inconsistent outcomes adopted to determine postoperative quadriceps strength. We found that those who underwent LR tended to achieve better postoperative quadriceps strength. Five of the studies included reported postoperative quadriceps strength. Dalury et al[16] have adopted a two-way [exposure type (eversion and subluxation) × time] analysis of quadriceps strength, revealing no significant differences between the groups at each postoperative follow-up interval. Umrani et al[10] have utilized Baltimore Therapeutic Equipment Primus (BTE® Primus, Baltimore, MD, USA) to assess quadriceps force and power at each follow-up visit and found that both groups possess similar quadriceps power and force values at each corresponding follow-up visit. Jenkins et al[11] have also shown no marked difference in isometric quadriceps strength between the two groups, which is measured using a Biodex dynamometer (Shirley, NY, USA). However, Majima et al[17] have found that the peak isometric torque of the quadriceps muscle achieves recovery at a faster rate in the LR group compared with the PE group. There are no significant differences between quadriceps muscle strength and knee ROM at 3 months after surgery.

To further investigate the impact of PE on postoperative knee recovery, we explored improvement in knee function using the Knee Society Function score and ROM of the knee. No difference was found between PE and LR in the Knee Society Function score. However, our pooled results demonstrated that LR achieved a larger ROM than PE. In addition, Majima et al[17] have shown that the average knee ROM is larger in the LR group at 4 weeks after surgery.

Therefore, our meta-analysis showed that PE in TKA negatively affected early postoperative knee rehabilitation. This finding could be explained by the excessive stretching of the quadriceps and patellar tendon during surgery, which led to early edema and fibrosis. However, functional differences between the groups disappeared 3 months post-operation.

Anterior knee pain, which decreases patient satisfaction and expectations, has been increasingly recognized as an essential phenomenon[22,23]. Our study found no significant differences in anterior knee pain, which was determined using VAS and Knee Society pain score. A systemic review[24] has shown that variables affecting the prevalence of anterior knee pain include patellar handling (patellar resurfacing and electrocautery of the patellar rim), operative technique, prosthetic design, and patient and knee-specific characteristics. At the same time, serious genu varus and valgus deformity will also affect the results of TKA[25].

The Insall-Salvati ratio, described by Insall and Salvati[26], was adopted in our study to evaluate radiographic outcomes. No differences were found between PE and LR. Moreover, our pooled results showed similar rates for the occurrence of patella baja in the two groups. However, some studies[27,28] have shown that LR may avoid the development of patella baja. Jenkins et al[11] have found no differences in the change of patellar tilt between the preoperative and postoperative periods between the groups (p=0.77). Majima et al[17] have indicated no significant differences in the mechanical axis, lower leg alignment, and angles of the component. In a cadaver study, Luring et al[29] have shown that PE may enhance valgus alignment in extension and 90° flexion. However, Kamei et al[30] have demonstrated that the flexion-gap inclination is markedly increased in LR compared with PE, indicating that the femoral component takes on a more externally rotated position.

In addition, our findings did not reveal any differences between postoperative or intra-operative complications or duration of hospitalization between the two groups. Nevertheless, a matched-pair cadaver study[27] has found that 100% of specimens that undergo PE develop a partial failure of the patellar tendon. In comparison, the same occurs in only 57% of those subjected to LR. It is important to note that a cadaveric model does not entirely accurately reflect physiological conditions given the exposure of the knee to for-

malin and the removal of soft tissues. Our pooled results indicated that the tourniquet time in PE was shorter than in LR, which might be attributed to better surgical exposure, permitting a more effortless and faster procedure.

Compared with previous reviews[12-14,31], this meta-analysis possessed some advantages. Firstly, this meta-analysis was conducted on 10 studies[6-12,16-18] consisting of 782 patients and 823 knees. Therefore, the large sample size used might reduce the occurrence of bias. Secondly, postoperative knee extensor function, measured using SLR and postoperative quadriceps strength, was adopted as the primary outcome for our meta-analysis, enabling more detailed scrutiny of the differences between PE and LR. Notably, compared with the latest meta-analysis[31], we included the evaluation of postoperative knee function, making our study a higher reference value for clinicians. Thirdly, general methodological quality was evaluated using Cochrane Collaboration recommendations, which is more accurate than the Jadad algorithm[12].

Limitations

On the other hand, this study also had several limitations. Firstly, our study included a relatively small number of studies, precluding our ability to construct funnel plots to assess publication bias. Secondly, performance bias could not be ruled out due to the various types of prostheses. Thirdly, three different surgical approaches were adopted across the studies, which might create surgeon bias and reduce the accuracy of the conclusions.

Conclusions

As the latest meta-analysis with the most significant numbers of trials and patients who underwent either PE or LR, our findings suggested that LR could achieve better early postoperative knee function. Furthermore, the clinical and radiographic outcomes 3 months post-operation were similar in both groups. Collectively, these findings indicated that LR was superior to PE in TKA. However, further studies are necessary to validate these results.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Funding

Qingdao Traditional Chinese Medicine Science and Technology Project; Grant number: 2021-zyym28; Science and technology Development Project of Shandong Geriatric Society; Grant number: LKJGG2021W082; Youth Research Foundation of Affiliated Hospital of Qingdao University; Grant number: QDFYQN202001012.

Availability of Data and Materials

All data generated during this study are from previously published studies.

Authors' Contribution

Tao Li, Yingzhen Wang, Haining Zhang contributed to the conception and design of the study. Yaping Jiang and Dong Liu performed the search and data extraction. Weipeng Shi and Bin Jia performed the data analyses and wrote the manuscript. All authors read and approved the final manuscript.

Ethics Approval

Not applicable.

Informed Consent

Not applicable.

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