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 disease1-3. 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 function4. Therefore, lateral retraction (LR) (Figure 1B) has been proposed in TKA to reduce detrimental effects caused to the extensor mechanism. Some studies5-9 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 investigations10,11 have shown that PE does not adversely affect quadriceps recovery following TKA.

Furthermore, two meta-analyses12,13 have revealed that both these procedures do not significantly affect post-TKA outcomes. In contrast, one meta-analysis14 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
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 5.0.215. 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 RCTs6-12,16-18 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 trials9,17-19, 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.
Table I. Characteristics of included studies.

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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\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{3,8,10,11,17,19} 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\textsuperscript{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\textsuperscript{2} 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.

\begin{itemize}
  \item Meta-Analysis Results
  \item Postoperative knee extensor function
  \item SLR and postoperative quadriceps strength were adopted as the primary outcomes to evaluate postoperative knee extensor function. Five studies\textsuperscript{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.
  \item Improvement in knee function
  \item Three RCTs\textsuperscript{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).
  \item Pain (VAS and Knee Society pain score)
  \item Six studies\textsuperscript{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).
\end{itemize}
### 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.
in quadriceps strength, complications, SLR, VAS, and functional scores. Jia et al.\(^1\) 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.\(^1\) 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 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. Umrami et al 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 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 have indicated no significant differences in the mechanical axis, lower leg alignment, and angles of the component. In a cadaver study, Luring et al have shown that PE may enhance valgus alignment in extension and 90° flexion. However, Kamei et al 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.

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 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. Our study found no significant differences in anterior knee pain, which was determined using VAS and Knee Society pain score. A systemic review 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.

The Insall-Salvati ratio, described by Insall and Salvati, 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 have shown that LR may avoid the development of patella baja. Jenkins et al have indicated no significant differences in the change of patellar tilt between the preoperative and postoperative periods between the groups (p=0.77). Majima et al have indicated no significant differences in the mechanical axis, lower leg alignment, and angles of the component. In a cadaver study, Luring et al have shown that PE may enhance valgus alignment in extension and 90° flexion. However, Kamei et al 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 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\textsuperscript{2-14,31}, this meta-analysis possessed some advantages. Firstly, this meta-analysis was conducted on 10 studies\textsuperscript{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\textsuperscript{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\textsuperscript{12}.

\textbf{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.

\textbf{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.

\textbf{Conflict of Interest}

The Authors declare that they have no conflict of interests.

\textbf{Funding}

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\textbf{Availability of Data and Materials}

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

\textbf{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.

\textbf{Ethics Approval}

Not applicable.

\textbf{Informed Consent}

Not applicable.

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