Knee Surg Sports Traumatol Arthrosc (2016) 24:921–930
DOI 10.1007/s00167-015-3528-5

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Patellar non-eversion in primary TKA reduces the complication rate

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Received: 11 September 2014 / Accepted: 30 January 2015 / Published online: 13 February 2015

Abstract
Purpose This study was designed to evaluate the isolated benefits of patellar non-eversion in total knee arthroplasty (TKA).
Methods This systematic review and meta-analysis was conducted following the PRISMA statement. A comprehensive search of the MEDLINE/PubMed, Cochrane Library, and Embase databases was performed in August 2014. Randomized controlled trials (RCTs) that considered the handling of the patella as the only variable were included in our review. Quality assessment of RCTs was performed according to the CONSORT statement. The meta-analysis was performed to pool the available data for some parameters.
Results The searches of the MEDLINE/PubMed, Cochrane Library, and Embase databases yielded 10 RCTs, and five RCTs were selected for inclusion in the review. This results suggested that tourniquet time [mean difference (MD) = −5.69; 95 % confidence interval (CI) −9.77 to −1.60], length of hospitalization (MD = 1.24; 95 % CI 0.54–1.94) and the incidence of complications [odds ratio (OR) = 2.23; 95 % CI 1.12–4.44] differed significantly between the eversion group and non-eversion group. No differences in postoperative pain, alignment, and the Insall–Salvati ratio were observed between the groups.
Conclusion The patellar non-eversion approach offers a shorter length of hospitalization and lower incidence of postoperative complications, but requires more operative time. The merits of patellar non-eversion for recovery of knee function remain controversial, and more high-quality RCTs are needed to draw clear conclusions. In general, avoidance of patellar eversion is recommended when exposing the knee joint for TKA.

Keywords Total knee arthroplasty · Patellar eversion · Patellar non-eversion · Minimally invasive surgery

Introduction

Traditionally, a standard medial para-patellar approach in primary total knee arthroplasty (TKA) produced good postoperative outcomes. In recent years, towards the goal of "minimally invasive surgery" (MIS), several modifications to the traditional approaches have been proposed. Studies have suggested that less invasive TKA results in superior immediate outcomes, including more rapid and better functional recovery and decreased postoperative pain [1, 9, 10, 17, 22], and yet seems to offer no significant improvements in the motion of the knee a few weeks after surgery [1, 22].

The exposure technique is a key procedure in both traditional and less invasive TKA and is intimately associated with postoperative clinical outcomes for patients as well as operational difficulty for surgeons [4, 5]. As a main element of the traditional medial para-patellar approach, patellar eversion has been theorized to afford sufficient exposure but to damage the quadriceps muscle due to tension and torsion [4], to shorten and scar the tendon [15], and to lead

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to complications such as patellar baja [6, 16]. Meanwhile, as a MIS technique, avoidance of patellar eversion has been employed more often in recent years and is expected to prevent postoperative muscle weakness and promote recovery of knee function [4, 5]. Unfortunately, from the results of studies evaluating MIS as a whole, it has been impossible to determine the advantages of the patellar non-eversion technique within less invasive strategies.

Following a call for studies isolating the variable of patellar eversion (with or without) [8, 14], several randomized clinical trials (RCTs) were performed comparing outcomes of surgeries in which only the handling of the patella was different [2, 7, 14, 18, 21]. However, the conclusions of these comparisons remain controversial. The aim of our study was to review RCTs isolating the effect of this technique (with vs. without patellar eversion) to evaluate the benefits of patellar non-eversion and guide clinical practice in TKA surgery. We hypothesized that patellar non-eversion during primary TKA would result in a more rapid postoperative recovery and better clinical outcomes and conducted a systematic review and meta-analysis to test this hypothesis.

Materials and methods

The aim of this review was to answer the following question: whether non-eversion compared to eversion of the patella during TKA leads to better clinical outcomes? In order to investigate this question normatively, the PRISMA statement [12] was followed in conducting this systematic review and meta-analysis. We performed a comprehensive search of the MEDLINE (PubMed) (1990—August 23, 2014), Embase (1990—August 23, 2014), and Cochrane Library (1990—August 23, 2014) databases, employing the following search terms and Boolean operators: "TKA" OR "total knee arthroplasty" or "TKR" OR "total knee replacement" and "eversion" or "everted" or "evert" and "patellar". The search terms could be used repeatedly. Only studies that met all of the following criteria were included: (1) published in English; (2) designed as a randomized controlled trial; (3) formally published; (4) published between 1990 and 23 August 2014; (5) included a follow-up period of more than 3 months; (6) included only patients of all ages and gender who required primary TKA; (7) independent from other studies to avoid giving double weight to some studies; and (8) specially addressed the effect of patellar eversion on outcomes of TKA. The excluded literature included: (1) unoriginal studies; (2) conference abstracts; (3) studies not comparing non-eversion and eversion of the patella during TKA; and (4) studies in which the non-eversion and eversion groups received TKA through different procedures.

Two reviewers independently reviewed the primary search results. Titles and abstracts were screened initially to assess their suitability for this study. Full texts were reviewed subsequently based on the established inclusion criteria. Any disagreements were resolved by consensus. All excluded studies were examined repeatedly through the process above by the other two reviewers.

The quality of the included studies was assessed using the CONSORT statement, which was designed by the CONSORT Group for assessing RCTs [3, 13]. Each included study was independently examined by two reviewers. One score was added when there was enough support information for a criterion, and no score was awarded when the study did not meet the requirements. Any disagreements between reviewers were resolved by discussion. Notably, we followed the requirement of every criterion strictly to ensure the quality of the studies included. If some details such as baseline data were not provided in the specific part required in the criterion, no score was awarded.

Data extraction was completed by two reviewers according to a pre-developed data extraction form. Items in this form included authors and publication year, study design, participants, intervention, parameters, and results. For continuous outcome variables, mean and standard deviation values were extracted, whereas numbers of events were extracted for dichotomous outcome variables. In this review, we analysed differences in the tourniquet time, length of hospitalization, postoperative quadriceps strength, range of motion (ROM), maximum extension/flexion, return of the ability to raise the straightened leg, knee functional scores, postoperative pain, alignment, Insall–Salvati ratio, and rate of complications.

The meta-analysis was performed using Review Manager (RevMan) version 5.2.6 (Cochrane Collaboration, Oxford, UK). Forest plots are utilized for the presentation of statistical results. Heterogeneity was evaluated by the Q statistic (Chi-square test) and I^2 statistic. If the P value of the Chi-square test was <0.1, we considered that heterogeneity existed in the test. Then, analyses to find the cause of such heterogeneity were performed. Random effects were considered when statistic heterogeneity existed rather than clinic heterogeneity. Otherwise, fixed effects were taken. The bias of publication date was tested by Egger's test.

Results

Study identification and inclusion

The search was completed on 23 August 2014. A flow diagram of the search strategy is shown in Fig. 1. Eventually, five studies were deemed suitable for inclusion and divided into two groups. Three studies performed by Arnout et al.

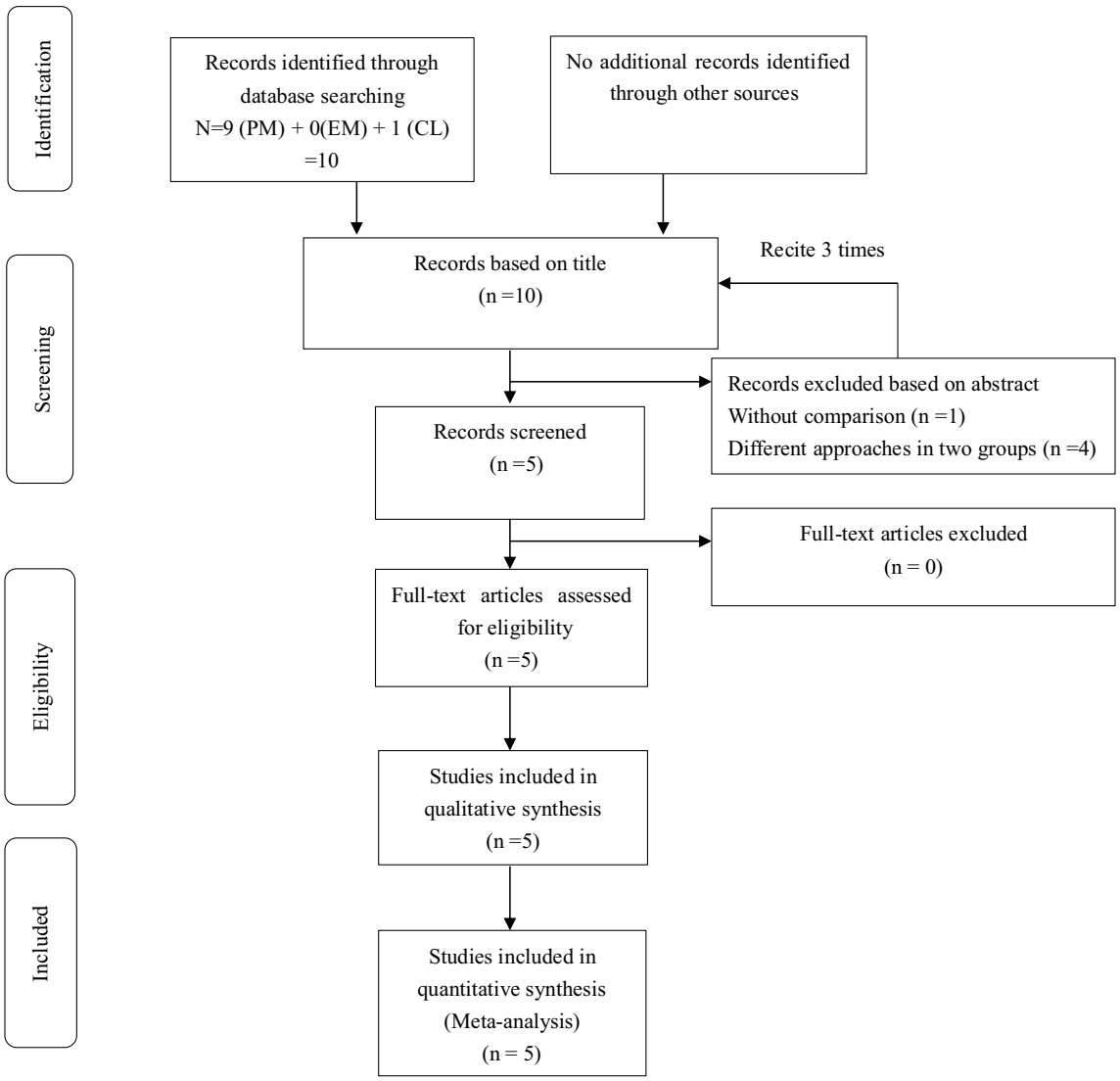

Fig. 1 PRISMA flow diagram. *PRISMA*, preferred reporting items for systematic reviews and meta-analyses; *PM* PubMed, *EM* Embase, *CL* Cochrane Library

[2], Jenkins et al. [7], and Reid et al. [14] were included in Group A. Participants in these studies were treated through a medial para-patellar approach with or without patellar eversion, in which the quadriceps tendon needed to be incised. Meanwhile, Group B contained two articles published by Umrani et al. [18] and Walter et al. [21]. Participants of these two studies were treated through the modified mid-vastus approach with patellar eversion or non-eversion. During surgery, the vastus medialis obliquus muscle was split from the superior medial patella, which injured the muscle but preserved the supra-patella tissue and quadriceps tendon. This difference between the two surgical approaches may lead to higher heterogeneity [19] and is the reason we divided these five studies when performing our analysis. The quality of the studies included in the review was assessed by two independent researchers, and the results were confirmed by mutual consensus. The results of the quality assessment based on the CONSORT statement are provided in Table 1.

Data extraction sheets for each study were completed by two independent researchers. The basic information (Table 2) and characteristics (Table 3) of the articles included in this study are provided. A total of 442 knees were included in this systematic review and meta-analysis of five RCTs.

Tourniquet time

Two studies [2, 7] in Group A and one study [18] in Group B reported results for tourniquet time, and among these,

Table 1 Quality assessment of selected articles based on the CONSORT statement and number (%) of studies achieving each

References	Item number											
	1	2	3	4	5	6	7	8	9	10	11	12
Reid et al. [14]	*	*	*	*	*	*	*		*		*	*
Umrani et al. [18]	*	*	*	*		*	*		*		*	*
Arnout et al. [2]	*	*		*		*			*		*	*
Jenkins et al. [7]	*	*		*		*	*		*		*	*
Walter et al. [21]	*	*		*		*	*		*		*	*
N (%) of studies achieving criteria	5 (100.00)	5 (100.00)	2 (40.00)	5 (100.00)	1 (20.00)	5 (100.00)	4 (80.00)	0 (0.00)	5 (100.00)	0 (0.00)	5 (100.00)	5 (100.00)

References	Item number										
	13	14	15	16	17	18	19	20	21	22	Total scores
Reid et al. [14]	*	*	*		*		*	*	*	*	18
Umrani et al. [18]					*		*	*		*	13
Arnout et al. [2]					*		*	*		*	11
Jenkins et al. [7]	*				*		*	*		*	13
Walter et al. [21]			*		*		*	*		*	13
N (%) of studies achieving criteria	2 (40.00)	1 (20.00)	2 (40.00)	0 (0.00)	5 (100.00)	0 (0.00)	5 (100.00)	5 (100.00)	1 (20.00)	5 (100.00)	68 (61.82)

Table 2 Characteristics of the studies included in our analysis

References	Total scores	Follow-up time	Drop-out rate (%)	Mean of intervention	Surgical approach	Country	Number of patients	Study design
Reid et al. [14]	18	1 year	2.94	PE & LR*	Standard MPP*	Australia	68	RCT
Arnout et al. [2]	11	1 year	0.00	PE & PS*	Standard MPP	Belgium	60	RCT
Jenkins et al. [7]	13	1 year	27.5	PE & LR	Standard MPP	America	120	RCT
Umrani et al. [18]	13	1 year	0.00	PE & PS	MVS	Korea	72	RCT
Walter et al. [21]	13	3 months	0.00	PE & non-PE	MVS	America	122	RCT

PE patellar eversion, *MVS* mid-vastus split, *MPP* median para-patellar, *LR* lateral retraction, *PS* patellar subluxation

Arnout et al. in Group A showed that the tourniquet time was shorter ($P = 0.005$) in the eversion group. The other studies indicated no significant difference in tourniquet time between the eversion and non-eversion groups. Upon pooling the results of these studies in the present analysis, we observed that patellar non-eversion increases the tourniquet time, as illustrated in Fig. 2 ($P = 0.006$).

Length of hospitalization

Of four RCTs that reported results for the length of hospitalization, one [7] in group A reported that the mean hospitalization time was significantly shorter ($P = 0.03$) in the non-eversion group (4.0 ± 1.4 days) compared to the eversion group (4.8 ± 2.6 days). The other studies

Table 3 Characteristics of included studies

References	Participants	Intervention	Index	Result
Reid et al. [14]	Number of knees: 68 enroled; 66 included Age: Eversion Group 68 (48–81) years; non-eversion Group 70 (55–87) years BMI: Not provided Gender (M:F): 28:38 Exclusion criteria: 1. Body mass index >40 2. Non-dislocatable patellar (e.g. secondary to patella baja or obesity) 3. Domicile was outside of Western Australia 4. Previous femoral fracture, the need for patellar resurfacing	Standard medial para-patellar approach assigned to patellar non-eversion group or patellar eversion group	A: Mean passive knee flexion B: Maximum passive knee extension C: Short form-12 score D: Oxford hip score E: Radiographic assessment of alignment and patellar height F: Visual analogue scale pain score G: Length of hospital stay	Percentage of lateral tibial overhang ($P = 0.005$)and maximum passive knee extension was improved greatly ($P = 0.034$) in the eversion group postoperatively, but both were not clinically significant while the maximum passive knee extension was improved ($P = 0.034$) Other indexes showed no significant difference between two groups Complications: 1. Two injuries to the patellar tendon in the non-eversion group; none in the eversion group
Arnout et al. [2]	Number of knees: 61 enroled; 60 included Age: Eversion group 67 ± 8 years; non-eversion group 64 ± 8 years BMI: Eversion group 28.2 ± 4 kg/m^2; non-eversion group 31.0 ± 8 kg/m^2 Weight: Eversion group 78 ± 15 kg; non-eversion group 84 ± 22 kg Length: Eversion group 167 ± 8 cm; non-eversion group 164 ± 6 cm Gender(M:F): 31:30 Exclusion criteria: 1. Frontal-plane >15° 2. >15° of flexion contracture 3. Flexion limited to <90° 4. Previous arthrotomy except for open meniscectomy 5. With rheumatoid disorders	Standard medial para-patellar approach assigned to patellar non-eversion group or patellar eversion group	A: Knee Society score B: Passive and active range of motion C: Quadriceps strength D: Radiographic assessment of alignment E: Percentage of patients able to perform a straight-leg raise F: WOMAC score G: Proprioception measurement H: Length of hospital day I: Visual analogue scale J: Insall–Salvati ratio	Passive ($P = 0.003$) and active ($P = 0.005$) range of motion values were larger in non-eversion group Other indexes showed no significant difference between two groups Complications: 1. One temporary peroneal nerve palsy in the non-eversion group 2. One non-fatal cerebralvascular incident, one epidural block, and One patellar fracture in the eversion group

Table 3 continued

References	Participants	Intervention	Index	Result
Jenkins et al. [7]	Number of knees: 120 enroled; 85 included Age: Eversion group 60 ± 6.3 years; non-eversion group 60 ± 7.5 years BMI: Eversion group 31.3 ± 6.3 kg/m^2; non-eversion group 32.4 ± 6.7 kg/m^2 Gender(M:F): 73:47 Exclusion criteria: 1. Ipsilateral total knee replacement, knee arthrotomy, osteotomy at or about the knee 2. Preoperative angular deformity >20°	Standard medial para-patellar arthrotomy assigned to patellar non-eversion group or patellar eversion group	A: Passive range of motion B: Visual analogue scale pain score C: Short form-36 score D: Length of hospital stay E: Insall–Salvati ratio F: Straight-leg raise G: Quadriceps strength H: Patella baja and patella tilt I: Walking distance	At 3-month follow-up, length of hospital stay ($P = 0.03$) was longer, but quadriceps strength ($P = 0.04$) was improved in the eversion group Other indexes showed no differences between the two groups Complications: 1. Seven pulmonary emboli in the eversion group and one pulmonary emboli in the non-eversion group ($P = 0.03$) 2. Two partial avulsions of the patellar tendon insertion in the eversion group 3. Nine cases of postoperative stiffness in the eversion group and six cases of post-operative stiffness in the non-eversion group 4. Four patients in the eversion group and five patients in the non-eversion group suffered anterior knee pain or retropatel-lar pain 5. Two cases of impaired skin healing in the eversion group. 6. Three cases of painful crepitus in the eversion group and one
Umrani et al. [18]	Number of knees: 99 enroled; 72 included Age: Eversion group 66.7 ± 6.6 years; non-eversion group 64.3 ± 6.9 years BMI: Eversion group 28.78 ± 3.86; non-eversion group 27.63 ± 3.46 Gender: All female Exclusion criteria: 1. Severe flexion deformity >30° 2. Inflammatory arthritis 3. Neuromuscular involvement 4. Haemophilia 5. Age >80 years 6. Primary osteoarthritis with valgus deformity of the knee	Modified mid-vastus approach assigned to patellar non-eversion group or patellar eversion group	A: Knee Society score B: Range of motion C: Short form-36 score D: Quadriceps strength and power E: Radiographic assessment of alignment	No difference between the two groups complications: None

Table 3 continued

References	Participants	Intervention	Index	Result
Walter et al. [21]	Number of knees: 134 enroled; 122 included Age: A1 group* 75.7 ± 9.47 years; A2 group* 71.5 ± 9.82 years; B1 group* 63.0 ± 10.45 years; B2 group* 66.6 ± 10.20 years; BMI: A1 group 31.3 ± 7.14 kg/m^2; A2 group 31.8 ± 4.37 kg/m^2; B1 group 35.5 ± 8.88 kg/m^2; B2 group 34.8 ± 8.47 kg/m^2; Gender (M:F): 33:89 Exclusion criteria: Not mentioned	Modified mid-vastus split assigned to patellar non-eversion group or patellar eversion group	A: Visual analogue scale pain score B: Length of hospital day C: Straight-leg raise D: Walking distance	Return of ability for straight-leg raise was slower in the eversion group ($P < 0.05$). Other indexes showed no difference between the groups Complication: 1. One patellar tendon rupture in the A1 group 2. One early postoperative infection in the A2 group

* A1 group: mid-vastus split with patellar eversion; A2 group: mid-vastus split without patellar eversion; B1 group: mid-vastus split without patellar eversion; B2 group: median para-patellar approach without patellar eversion

reported no difference between the groups. The RCT performed by Arnout et al. [2] in Group A was excluded from the meta-analysis of this variable due to reporting of insufficient data. The remaining two RCTs in Group A were pooled with a relatively high heterogeneity ($I^2 = 57$ %; $P = 0.0005$), as shown in Fig. 3.

Complications

Various postoperative complications were recorded by all five RCTs [2, 7, 14, 18, 21]. After dividing the studies into two subgroups, the total rates of complications were extracted and pooled for the eversion and non-eversion groups. The results of this analysis (Fig. 4) indicated better outcomes in the non-eversion group (pooled OR: 2.23; 95 % CI 1.12–4.44; $P = 0.02$).

Other measurements that are mentioned in the five RCTs are listed in Table 3.

Discussion

As a MIS technique, the patellar non-eversion technique was introduced to avoid the harmful effects of patellar eversion [4, 5]. Although a few RCTs have been performed to compare TKA with or without patellar eversion, their conclusions are inconsistent. Therefore, we conducted this systematic review and meta-analysis to evaluate the isolated benefits of patellar non-eversion in TKA.

Within this systematic review, we evaluated the functional recovery of the quadriceps muscle and tendon. The strength and power of the quadriceps were evaluated by Umrani et al. [18] and Jenkins et al. [7] and showed no statistically significant differences between the eversion and non-eversion groups at the 1-year postoperative follow-up. However, Jenkins et al. reported that quadriceps strength showed greater improvement in the eversion group at 3 months postoperatively. Another variable associated with quadriceps force and tendon conditions, knee joint ROM, has drawn the attention of more researchers. Arnout et al. [2] in 2009 suggested that the ROM was greater in the non-eversion group at the 1-year follow-up, but subsequent studies indicated that the ROM did not differ significantly at the 1-year follow-up between the eversion and non-eversion groups [7, 18]. Notably, Arnout et al. employed a posterior cruciate ligament (PCL) sacrificing technique, whereas the other two studies used a PCL retaining strategy. PCL retention was believed to limit the operative exposure and to increase the surgical difficulty, which decreases the benefits of the non-eversion approach [20]. Controversially, Reid et al. [14] in 2014 reported a significant difference in the maximum extension attained 3 months after surgery, with $-3.9° \pm 1.12°$ in the eversion group and $-2° \pm 0.91°$ in

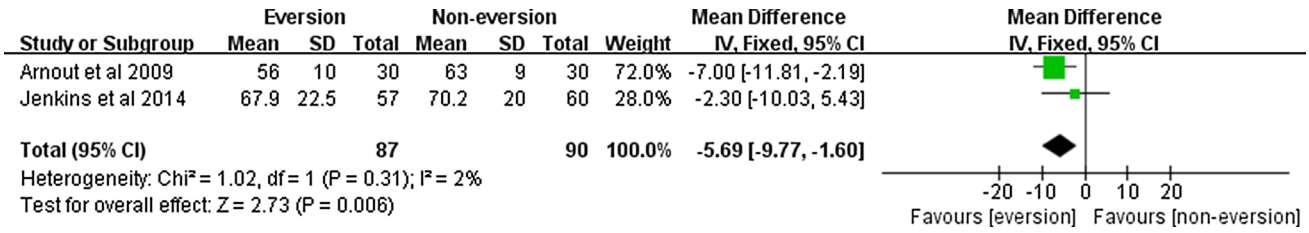

Fig. 2 Forest plot of tourniquet time

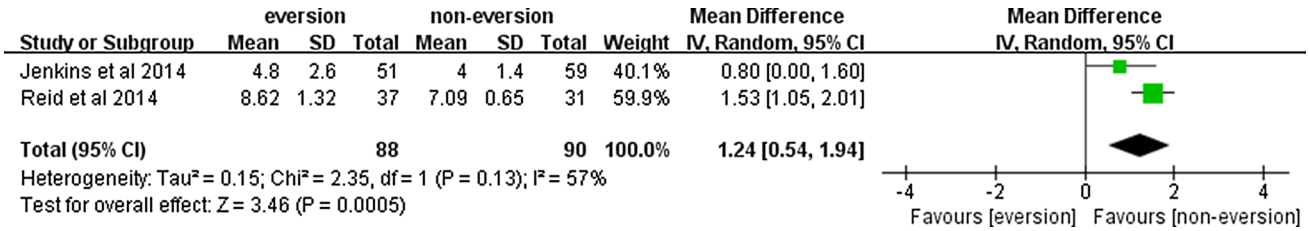

Fig. 3 Forest plot of length of hospitalizaiton

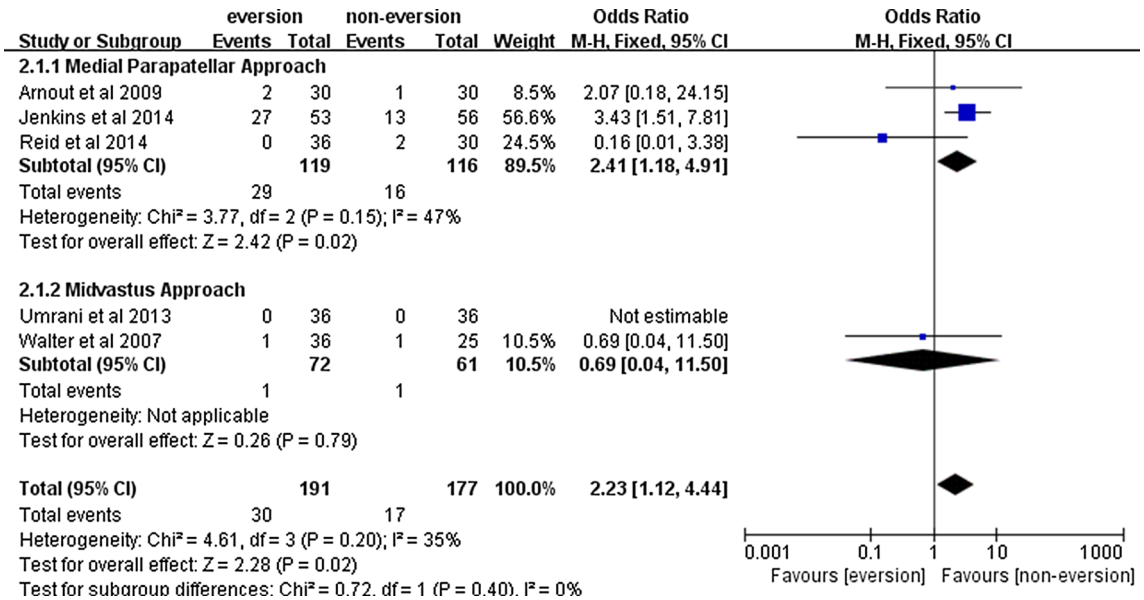

Fig. 4 Forest plot of complications

the non-eversion group ($P = 0.034$). However, this difference disappeared by 1 year after surgery. In addition, Walter et al. [21] provided evidence that the return of the ability to raise the straightened leg was slower in the eversion group at an average of 8.9 h after the surgery, but another study reported no significant difference in this ability between the groups at 72 h postoperatively [8]. The postoperative results for other indexes, including the Oxford Hip score (OHS), Western Ontario and McMaster Universities Arthritis Index (WOMAC) score, Knee Society score (KSS), and postoperative walking distance, did not differ significantly between the eversion and non-eversion groups in these RCTs [2, 14, 18].

With respect to postoperative pain, data for the Knee Society pain score (KSPS) and visual analogue scale score provided no evidence to support a significant difference in postoperative pain between the eversion and non-eversion groups [7, 14, 21]. This finding suggests that avoiding

patellar eversion contributes little to relieving patients' pain after surgery.

In addition, some radiographic evaluations were performed in these studies. As an important index, alignment did not differ significantly between the eversion and non-eversion groups in three RCTs [2, 14, 18]. The Insall–Salvati ratio also did not differ significantly between the eversion and non-eversion groups [2, 7, 14]. One study [21] was excluded from our meta-analysis of this variable because specific data were unavailable. The RCT performed by Jenkins et al. [7] showed lower Insall–Salvati ratios both preoperatively and postoperatively in the eversion group, but changes from preoperatively to postoperatively were not different between groups. Hence, we could not ensure and merge the benefits of the patellar non-eversion technique on the Insall–Salvati ratio in this study due to this inconsistency in the baseline data of patients.

Data for the outcome variables discussed above were not pooled for meta-analysis in our study, due to a lack of sufficient specific data reported in the included studies. With the corresponding conclusions remaining controversial, more RCTs including more samples and employing consistent detection methods are needed to ascertain the benefits of patellar non-eversion.

Our meta-analysis was based on five RCTs published between 2009 and 2014. Our results indicated that the tourniquet time, which is associated with an increase in the incidence of surgical site infection [11], was significantly longer ($P = 0.006$) in the non-eversion group. However, the length of hospital stay was significantly prolonged ($P = 0.0005$) in the eversion group. For evaluation of postoperative complications, we divided the included RCTs into two subgroups to reduce the heterogeneity. Significant differences ($P = 0.02$) were found in the medial parapatellar approach subgroup, which suggested that patellar eversion was associated with more complications after TKA. We noticed that our results for length of hospitalization ($I^2 = 57\ \%$) had high heterogeneity. As an approach to analyse studies with high heterogeneity ($I^2 > 50\ \%$ or $P < 0.1$), a random-effect model was applied to pool these two parameters.

Xu et al. [22] recently published a meta-analysis comparing minimally invasive and standard medial para-patellar approaches for TKA that included 32 RCTs. Their results suggested that operative time was longer in the mini-mid-vastus group, but no significant differences in length of hospitalization and postoperative complications were observed. In contrast, in our review, length of hospitalization and the incidence of postoperative complications were both significantly lower in the non-eversion group, and operative time was significantly longer in the non-eversion group. Compared to the meta-analysis of Xu et al., our study suggested that non-eversion of the patella during primary TKA using a minimally invasive approach may be a factor that increases operative time. However, the associations between patellar non-eversion and the minimally invasive approach with respect to length of hospitalization, and the rate of postoperative complications remain unclear.

Avoidance of patellar eversion is recommended as a better technique to expose the knee joint based on the results of this analysis. Although the benefits of this approach on functional recovery and postoperative pain are not well confirmed, this technique is associated with reductions in the length of hospitalization and complication rate. However, the following consideration should be noted. In planning TKA, inappropriate physical conditions always limit exposure of the surgical field, prolong the tourniquet time, and impact the clinical outcomes, which changes the merits of MIS [4, 5]. Our recommendation should be applied in patients with appropriate physical conditions, carefully considering BMI, muscle tone, and joint deformity.

To provide stronger supporting evidence, the MEDLINE (PubMed), Embase, and Cochrane Library databases were searched with concordant inclusion and exclusion criteria by two authors independently. Also, the RCTs provided level 1 evidence according to the current Cochrane Handbook. Quality assessment of the five included studies was performed independently by two authors according to the CONSORT statement, and any conflicting results were resolved by discussion. Although the RCTs considered the handling of the patella as the only variable, these five RCTs used two different approaches to surgical intervention. In this study, only results from RCTs using the same approach were pooled.

The present study has some limitations. First, articles not published in English were excluded in the screening process, which may have resulted in the exclusion of some other high-quality studies. Secondly, only five RCTs involving a total of 442 knees were included. Although the data extracted could be analysed, a larger sample size is needed in further studies.

Conclusion

With the aim of evaluating the benefits of patellar non-eversion during primary TKA, this review presents an overview of the tourniquet time, length of hospitalization, postoperative quadriceps strength, ROM of the knee joint, maximum extension/flexion, return of ability for straight-leg raise, knee functional scores, postoperative pain, alignment, Insall–Salvati ratio, and rate of complications. Based on our results, patellar non-eversion offers a shorter hospital stay and lower incidence of postoperative complications, but requires more operative time. Postoperative pain, alignment, and the Insall–Salvati ratio did not differ

between the patellar non-eversion and eversion groups. Additionally, the merits of patellar non-eversion for recovery of knee function remain controversial, and thus, more high-quality RCTs are needed to draw clear conclusions. In general, avoidance of patellar eversion is recommended to expose the knee joint in patients with appropriate physical conditions.

Acknowledgments The authors are pleased to acknowledge support from Professor Jing Tian. We are grateful for his enlightenment in the process of selecting the topic. Moreover, he took time from his busy schedule to give us valuable comments on a draft version of the paper. His instruction was of great help in the completion of our study.

Conflict of interest The authors declare that they have no conflicts of interest.

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