Personalized Tourniquet Inflation Pressure or Conventional Uniform Tourniquet Inflation Pressure During Total Knee Arthroplasty: A Meta-analysis of Randomized- Controlled Trials.

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Research article

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Abstract

Background Pneumatic tourniquets are widely used in total knee arthroplasty (TKA). Some surgeons prefer a uniform tourniquet inflation pressure (UTIP)for all patients; others use personalized tourniquet inflation pressures (PTIP). However, no consensus exists regarding the optimal mode of inflation pressure during TKA. This review aimed to appraise if personalized tourniquet inflation pressures are better than uniform tourniquet inflation.

MethodsThe databases (Web of Science、Embase、PubMed、Cochrane Controlled Trials Register,、Cochrane Library、Highwire、CBM、CNKI、VIP、Wanfang) were searched on August 2020 to systematically identify and screen the literature for randomized controlled trials (RCTs) involving PTIP and UTIP during total knee arthroplasty.

Results: Nine randomized controlled trials, involving 840 TKAs (837 patients) were included in the systematic review. The meta-analysis identified a trend toward less Visual Analogue Scale (VAS) score at rest with PTIP group at one day（P＜0.00001）、2-3day（P=0.01）, and less VAS score at activity 1day （P＜0.0001),2-3 days after the operation (P＜0.00001)and discharge (P＜0.0001). No significant difference was found between the groups in terms of VAS score at rest when discharge (P=1.0), intraoperative blood loss（P=0.9）, total blood loss（P=0.3）, Hospital for Special Surgery (HSS) score （P=0.05）, lower limb vein thrombosis （P=0.42）and thigh bullae（P=0.17）. However, in the PTIP group, we found a significant broader knee Range of motion(ROM)（P=0.02）and a reduction in the rate of thigh ecchymosis（P=0.0003）and thigh circumference at one day(P=0.006), 2-3day (P=0.0005), and discharge(P=0.02).

Conclusion: PTIP provides a similar bloodless surgical field compared with the conventional UTIP. Furthermore, PTIP provides less pain intensity, thigh circumference, rate of thigh ecchymosis, and better initial recovery of knee flexion in total knee arthroplasty. Therefore, we recommend using a PTIP method during TKA. More adequately powered and better-designed randomized controlled trials （RCTs）studies with long-term follow-up are required to produce evidence-based guidelines regarding the PTIP method.

Background

Pneumatic tourniquets that are used in total knee arthroplasty (TKA) may lead to soft tissue damage, including the skin, vessels, muscles, nerves, and fibrinolytic activity due to unnecessarily excessive inflation pressure[1][2][3][4]. However, many orthopedic surgeons use it. A study of the American Association of Hip and Knee Surgeons found that approximately 95% of surgeons used tourniquets during TKA [5].

The tourniquet can provide a clear bloodless field, which potentially reduces intraoperative blood loss, operative time and better prepares the cement-bone interface, despite the possible adverse effects associated with its use during total knee arthroplasty (TKA)[6]. The tourniquet use is almost indispensable in orthopedic practice. Although a lot of procedures employ the use of a tourniquet, there is still a lack of evidence-based guidelines of standard practice regarding optimal inflation pressures[7][8][9]. While some prefer a uniform tourniquet inflation pressure(UTIP) for all patients[10][11][12], others use personalized tourniquet inflation pressures (PTIP), which based on systolic blood pressure (SBP)[3][13][14] Limb occlusion pressure (LOP) or arterial occlusion pressure (AOP). This study aimed to compare the effects of the PTIP with conventional UTIP on rehabilitation outcomes in TKA patients.

Methods

Our meta-analysis was registered on PROSPERO (International prospective register of systematic reviews), and the registration number was CRD42020168432. We assessed the quality of the included studies according to the items recommended in Cochrane Collaboration (Revman 5.3; http://handbook.cochrane.org/), and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines

Search strategy

We identified relevant randomized controlled trials involving PTIP or conventional UTIP in total knee arthroplasty in electronic databases, including PubMed, Web of Science、Embase、Cochrane Controlled Trials Register,、Cochrane Library、Highwire、CBM、CNKI、VIP、Wanfang database, up to August 2020. The keywords included "total knee arthroplasty," "total knee replacement," " tourniquet," “pressure" in conjunction with Boolean operators "AND" or "OR." Review Manager Software was used to perform our meta-analysis.

Inclusion criteria

The inclusion criteria were: 1. The intervention was PTIP, based on systolic blood pressure or Limb occlusion pressure or arterial occlusion pressure in TKA; 2. The comparator was the UTIP based on surgeon experience ; 3. Randomized controlled trial studies; 4. The outcomes are intraoperative blood loss, total blood loss, VAS score, HSS score, knee ROM, thigh circumference, complication rates including lower limb vein thrombosis, thigh bullae, and thigh ecchymosis; 5. The follow-up rate was at least 80%. 6. At least one outcome was included in the study;

The exclusion criteria were as follows:1. Observational studies;2. non-RCTs; 3. The included studies have insufficient outcome data.

Data extraction process

Two reviewers independently extracted the available data from each study. The primary data were based on the following: first author, year of publication, country, number of TKAs and participants, age, gender, BMI, the primary indication for TKA, prosthesis, anesthesia, operation time, mean tourniquet time, mean inflation pressure, practices of tourniquet pressure, the time for loosening the tourniquet, tourniquet system, tourniquet cuff. The primary outcome consisted of Intraoperative blood loss, total blood loss, VAS score, HSS score, complications such as lower limb vein thrombosis, thigh bullae, and thigh ecchymosis. Secondary outcomes included knee ROM and thigh circumference.

We resolved the disagreements by discussion to reach a consensus.

Quality Assessment

We used the Cochrane risk of bias tool to assess the risk of bias in the RCTs and determine whether biases might have affected the results.

Statistical Analysis

Review Manager Software for MAC (version 5.3) was used to perform the meta-analysis. The Q test and I2 were used to evaluate the heterogeneity between studies. The random-effects model was in the place of the fixed effects model for heterogeneity test, P values $\leq .1$ or I2 $\geq$ 50%. The mean difference (MD) or standard mean difference (SMD) was used to assess continuous outcomes such as VAS, blood loss, Hospital for Special Surgery (HSS) score, knee range of motion(ROM), and thigh circumference with a 95% confidence interval (CI). We used Relative risks with a 95% CI to assess dichotomous outcomes such as rate of lower limb vein thrombosis, thigh bullae, and thigh ecchymosis. We considered the results as a statistically significant difference when P values were less than 0.05

Results

Search results

The detailed literature screening process is shown as the PRISMA flow diagram in Fig. 1. The literature search identified 489 citations. Of these, we removed 330 duplicates. Upon reviewing the titles and abstracts of the 159 remaining articles, we excluded 148 papers according to the inclusion criteria and retrieved the full text of 11 articles. Because sufficient data were not available in 2 articles, hence two studies were excluded. Finally, we identified 840 TKAs (837 patients) assessed in 9 randomized controlled trials[15][16][17][18][19][20][21][22][23] We presented the detailed baseline characteristics in table 1 and tourniquet intervention information in Table 2. All the papers were published in English and Chinese between the years 2005 and 2020.

Risk of Bias assessment

The risk of bias summary and bias graph for RCTs is shown in Figs. 2 and 3. The correct randomization and sufficient allocation concealment were adequately described in six studies. The blinding of outcome assessment was described in nine studies, and the blinding of participants and personnel was described in three studies. Each study retained complete outcome data and avoided selective reporting. Other potential biases of all studies can't be ignored. Therefore, we rated them as having an unclear risk of other bias. As a result, the included studies' overall quality was considered adequate (Fig. 2 and 3).

Pooled analysis of blood loss between the PTIP group and UTIP group

Three RCTs reported intraoperative blood loss and total blood loss. The results showed that both groups experienced similar intraoperative blood loss (MD=-0.47, 95% CI [-7.76,6.82], P=0.90 Fig. 4) and total blood loss (MD=-102.59, 95% CI [-298.09,92.91], P=0.30 Fig. 4).

Pooled analysis of VAS between PTIP group and UTIP group

we were able to detect a significantly lower VAS at rest 1day after operation(MD=-1.64, 95% CI [-1.87,-1.4], P<0.00001 Fig. 5) ,2-3 days after operation(MD=-1.02, 95% CI [-1.8,-0.23], P=0.01 Fig. 5) and lower VAS at activity 1day after operation(MD=-0.69, 95% CI [-1.02,-0.37], P<0.0001 Fig. 5) ,2-3 days after operation (MD=-1.18, 95% CI [-1.49,-0.87], P<0.00001 Fig. 5)and discharge (MD=-2.29, 95% CI [-3.33,-1.25], P<0.0001Fig. 5) in patients with personalized pressure group. The results of the meta-analysis showed that patients in both groups experienced similar VAS at rest when discharge from hospital (MD=-0.00, 95% CI [-0.74,0.74], P=1.0 Fig. 5).

Pooled analysis of complication rates between PTIP group and UTIP group

Our results showed that patients in both groups experienced similar rates of lower limb vein thrombosis (MD=-0.03, 95% CI [-0.1,0.04], P=0.42; Fig. 6) and thigh bullae (MD=-0.11, 95% CI [-0.28,0.05], P=0.17; Fig. 6),however we also detect a significantly lower rate of thigh ecchymosis (MD=-0.17, 95% CI [-0.26,-0.08], P=0.0003; Fig. 6)in patients with personalized pressure group.

Pooled analysis of HSS between PTIP group and UTIP group

Our results showed that patients in both groups experienced similar HSS scores (MD=1.49, 95% CI [0.01,2.97], P=0.05; Fig. 7).

Pooled analysis of ROM between PTIP group and UTIP group

We detected a significantly better knee ROM (MD=3.82, 95% CI [0.58,7.06], P=0.02; Fig. 8) in patients with personalized pressure group.

Pooled analysis of thigh circumference between PTIP group and UTIP group

We detected a significantly shorter thigh circumference 1 day after operation(MD=-3.08, 95% CI [-5.28,-0.88], P=0.006; Fig. 9),3day after operation(MD=-3.05, 95% CI [-4.78,-1.32], P=0.0005; Fig. 9) and 5 day after operation (MD=-0.51, 95% CI [-0.95,-0.07], P=0.02; Fig. 9) in patients with personalized pressure group.

Discussion

Although clinical efforts and advances in tourniquet technology have resulted in the use of lower inflation pressures, there was no meta-analysis comparing the effects of PTIP with UTIP on rehabilitation outcomes and postoperative complications. Our meta-analysis is the first meta-analysis to compare the impact of PTIP with conventional UTIP during TKA

The current meta-analysis's main finding was that both PTIP and conventional UTIP ensure equal blood loss in total knee arthroplasty. No significant difference was observed between the groups in terms of HSS, rate of lower limb vein thrombosis, and thigh bullae. However, in patients using a tourniquet with PTIP, we found a significant reduction in postoperative pain, thigh circumference, rate of thigh ecchymosis, and a better initial recovery of knee flexion.

The present work analysis was not able to identify any differences between the two groups in the case of intraoperative blood loss and total blood loss. These findings mean PTIP would provide a bloodless surgical field comparable to conventional UTIP.

Immediate postoperative pain relief following TKA is crucial in facilitating early recovery. We were able to detect a significantly lower pain intensity within three days after operation both at rest and during mobilization in patients with p PTIP group. We also identified a significantly lower pain intensity at the activity when patients were at discharge; however, we couldn't identify any difference of pain intensity at rest when patients left the hospital. An explanation for the increased pain in the early postoperative period with conventional uniform pressure group could be direct higher pressure on the surrounding soft tissues due to the tourniquet. In our study, the pressure of the PTIP is lower than the conventional UTIP group. Worland et al. [24]showed an essential correlation between tourniquet pressure and thigh pain in the immediate postoperative period. We thought that the PTIP lowers pain levels while increasing patients' adherence to rehabilitation, which resulted in earlier restoration in functions.

In patients using a tourniquet with PTIP, we found a significant reduction in thigh circumference. We think the reason may be due to less stress on the thigh muscles in the PTIP group.

Knee flexion ROM is often used to evaluate short-term effectiveness. Besides, discharge from the hospital is dependent on the mobility of patients following TKA. The PTIP group documented a significantly higher postoperative ROM. It may be related to using a conventional UTIP with higher tourniquet pressure that causes some temporary loss of flexibility in the tight thigh muscles. The analysis of the postoperative HSS did not reveal a difference. HSS might be affected by many factors such as pain, ROM, function, muscle force, and flexion deformity. Moreover, the effect of a personalized tourniquet application on HSS needs to be further confirmed by more high-quality studies.

As for complications, all studies did not experience major significant complications such as symptomatic PE, thigh necrosis, nerve palsy, or delayed rehabilitation. We found no significant difference between groups regarding the rate of lower limb vein thrombosis and thigh bullae. However, in patients using a tourniquet with personalized tourniquet inflation, we found a significant reduction in the quality of thigh ecchymosis and better initial recovery of knee flexion. It is possible to achieve functional benefits with decreasing some complications related to the tourniquet and to have the advantages as with the personalized tourniquet application.

The pressure for safe tourniquet use remains controversial, and no strict guidelines have been established. Most of the orthopedic surgeons routinely apply fixed tourniquet pressure in TKA based on individual experiences. It was very convenient to choose the fixed pressure value. However, it did not take patients' actual individual situation into account, so the selected pressure values were mostly on the high side. Some researchers suggested that upper limb pressure in an adult is 250 to 300 mm Hg, and lower limb pressure is 350 to 500 mm Hg [25]. A higher tourniquet pressure ensures the reliable function of the tourniquet; however, it may lead to a higher incidence of complications. The pressures higher than 350mmHg on the lower limbs increase neuropraxia and compression[8][13]. While a lower tourniquet pressure is safer than higher pressure, it may not provide a bloodless operative field. Optimal tourniquet pressure should be determined to balance safety and efficacy. In recent years, some investigators proposed that the tourniquet pressure setting should be personalized. Compression pressure on a pneumatic tourniquet's limb artery wall is different due to different physiological functions, such as systolic blood pressure, age, weight, limb circumference size, and muscle tissue thickness.

Setting the tourniquet pressure based on SBP, AOP, or LOP allows us to use a personalized tourniquet pressure in each patient and is useful in optimizing tourniquet cuff pressures. The rationale behind inflating the tourniquet beyond the SBP, allowing a certain amount of safety margin, which added to the SBP ranges widely, from 100 to 250 mmHg in the literature [26][27]. AOP and LOP are the terms that mean the lowest tourniquet pressure is required to cease the arterial blood flow into the extremity distal to the cuff. AOP can be estimated by a formula using a patient's systolic blood pressure (SBP) and tissue padding coefficient (KTP) values (AOP ¼ [SBP +10]/KTP)[28][29]. The guidelines of the Association of Perioperative Registered Nurses recommend that a safety margin of 80 mmHg should be added for AOP above 190 mmHg,60 mmHg for AOP between 131 mmHg and 190 mmHg, and

40 mmHg for AOP below 130 mmHg for adults [30]. LOP can be determined automatically or manually by slow cuff inflation to pulse cessation with diagnostic equipment such as Doppler flowmeter or pulse oximeter[31][32][33][34]. Now, modern tourniquet systems permit an automated LOP estimation through a probe incorporated in the tourniquet system itself [4]. However, these systems also have limitations such as the need for special equipment with additional cost, skilled personnel, and perioperative workload on the team [31].

Following an analysis of the current literature, this work demonstrated a relative predominance of the advantages when a tourniquet is used with the personalized application. However, the present meta-analysis has several limitations: First, there are three methods for personalized tourniquets, including SBP, AOP, and LOP. Because of the limited data, we were not able to evaluate one of them separately. We performed a sensitivity analysis on them and found that the conclusion is stable when removing one method. Second, the studies' comparability was complicated through the different measurement methods and follow-up examination time points; however, we have tried our best to evaluate results based on time points. Third, the tourniquet time, the time for loosening the tourniquet, and the cuff pressure used were also not uniform (see Tab. 1). Fourth, there are no worldwide uniform guidelines for performing total knee arthroplasty. Different surgical techniques (such as the selection of approach, methods of anesthesia, drainage patterns hemostasis, and anticoagulation regimens) were used in the individual studies.

Conclusion

In conclusion, personalized tourniquet inflation pressure provides a bloodless surgical field comparable to that of a conventional uniformed method with less pain intensity, thigh circumference, rate of thigh ecchymosis, and better initial recovery knee flexion in total knee arthroplasty. Therefore, we recommend using personalized tourniquet inflation pressure during TKA. However, due to the limited comparability of the studies available, more longer follow-up period and overall higher quality RCTs are needed to confirm the present meta-analysis results.

Abbreviations

UTIP: uniform tourniquet inflation pressure; PTIP: personalized tourniquet inflation pressures; CIs: Confidence intervals; RCTs: Randomized controlled trials; RR: Risk ratio; OR: odds ratio; VMD: Weighted mean difference; TKA: Total knee arthroplasty; OA, osteoarthritis; RA, rheumatoid arthritis; BMI, body mass index; SBP, systolic blood pressure; LOP: Limb occlusion pressure; AOP: arterial occlusion pressure; Hospital for Special Surgery (HSS); a range of motion(ROM).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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None.

Author contribution

Changjiao Sun, Xu Cai and Huadong Yang: Conceptualization Data curation; Formal analysis, Roles/Writing - original draft; Writing - review & editing

Qi Ma and Huimin Li: Data collection;Investigation; Methodology;

Xiaofei Zhang and Huimin Li: Resources; Software

Xu Cai and Huadong Yang: (co-corresponding author): supervised the whole study

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None

Data statement

All data in this study were derived from the original literature.

Conflict of Interest

All authors declare that they have no conflict of interest.

Ethical approval

Ethical approval was not necessary because the present meta-analysis was performed based on previously published studies.

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Tables

Table 1 The detailed baseline characteristics information

personalized tourniquet pressurel/conventional tourniquet pressure									
Author/year	**Country**	**Patients**	**Knees**	**Mean age(years)**	**Female gender(%)**	**BMI**	**Diagnosis**	**Prothesis**	**Anesthesia**
Ishii 2005	Japan	29/28	30/30	71/68	93.1/85.7	25.5/26.6	29OA,1RA/27OA,3RA	cementless TKA with New Jersey LCS	Spinal
Unver 2013	Turkey	17/21	17/21	68/67.3	82.4/85.7	30.8/32	17OA/21OA	(Nexgen; Zimmer, Warsaw, IN).	General
De Souza Leão 2016	Brazil	30/30	30/30	66/65.4	73.3/76.7	NA	30OA/30OA	Modular III® (MDT, Rio Claro, SP, Brazil),	Spinal
Geng 2014	China	61/60	61/60	NA	NA	NA	61OA/60OA	NA	NA
Lei 2019	China	36/35	36/35	67.42/68.86	80.6/80	24.67/24.84	36OA/35OA	CR Gemi MK (LINK, Germany)	General
Si 2018	China	88/82	88/82	NA	NA	NA	88 OA/82 OA	NA	General
Wu 2014	China	30/30	30/30	65.97/65.67	NA	23.26/23.74	30 OA/30OA	NA	Spinal
Zhang 2016	China	80/80	80/80	NA	NA	NA	80 OA/80OA	NA	General
zhou 2019	China	50/50	50/50	67/65.8	52/54	22.9/23	50 OA/50OA	A3(AKMEDICAL)	General

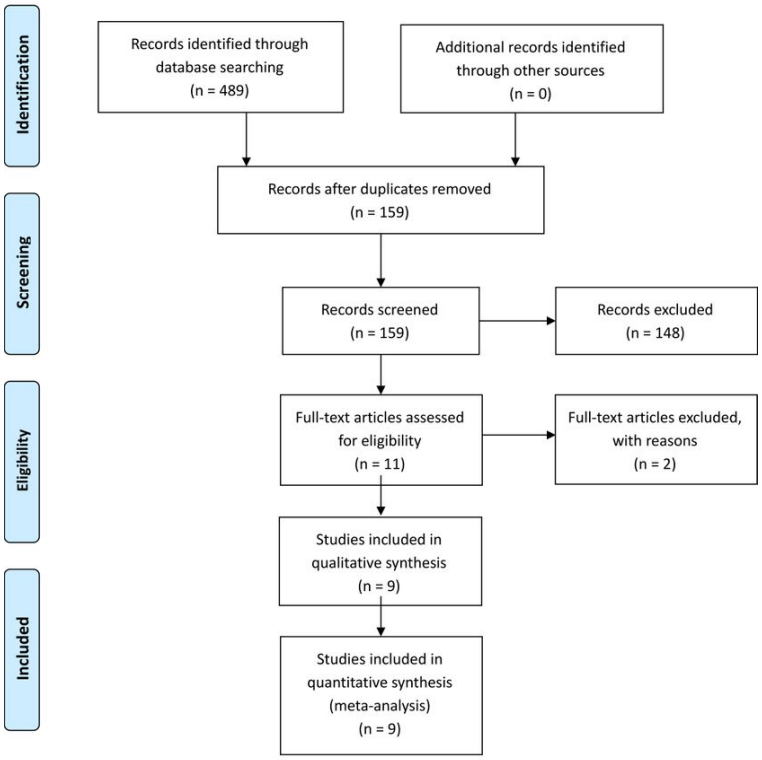
The detailed baseline characteristics information, including the number of TKAs, age, gender, BMI, diagnosis, prothesis, anesthesia of two groups.

Table 2 The tourniquet intervention information

		Personalized tourniquet pressurel/Conventional tourniquet pressure			
Author/year	Operation time(min)	Mean tourniquet time(min)	Mean Inflation pressure(mmHg)	Practices of tourniquet pressure	The time for loosening the tourniquet
Ishii 2005	71/72	48/50	238/350	100 mm Hg above SBP/350mmHg	Before the incision was closed
Unver 2013	NA	60/58.3	169.7/304.7	Arterial occlusion pressure estimation method/300mmHg	After the application of a wool and crepe bandage to the limb.
De Souza Leão 2016		118/110	NA	100 mm Hg above SBP/350mmHg	After Robert Jones dressing was made
Geng 2014	NA	NA	245/250	Limb occlusion pressure estimation method/250mmHg	NA
Lei 2019	NA	55.79/57.23	181.72/270	Limb occlusion pressure estimation method /270mmHg	After the application of a bandage to the limb.
Si 2018		59/59	340.425/487.5	Limb occlusion pressure estimation method/65kpa(487.5mmHg)	After the application of a bandage to the limb.
Wu 2014	NA	81.77/81.23	360.28/500	Limb occlusion pressure estimation method/500mmHg	NA
Zhang 2016	NA	59.61/59.84	333/487.5	Limb occlusion pressure estimation method/487.5mmHg	After the application of a bandage to the limb.
zhou 2019	NA	NA	NA	Limb occlusion pressure estimation method/525mmHg	After the application of a bandage to the limb.

The tourniquet intervention information including the operation time, Mean tourniquet time, mean inflation pressure, mean inflation pressure, practices of tourniquet pressure, the time for loosening the tourniquet, tourniquet system, and tourniquet cuff of two groups.

Figures



1

Figure 1

The search results and selection procedure. The literature search identified 489 citations. Of these, we removed 330 duplicates. Upon reviewing the titles and abstracts of the 159 remaining articles, we excluded 148 papers according to the inclusion criteria and retrieved the full text of 11 articles. Because sufficient data were not available in 2 articles, hence two studies were excluded. Finally, we identified 840 TKAs (837 patients) assessed in 9 randomized controlled trials.

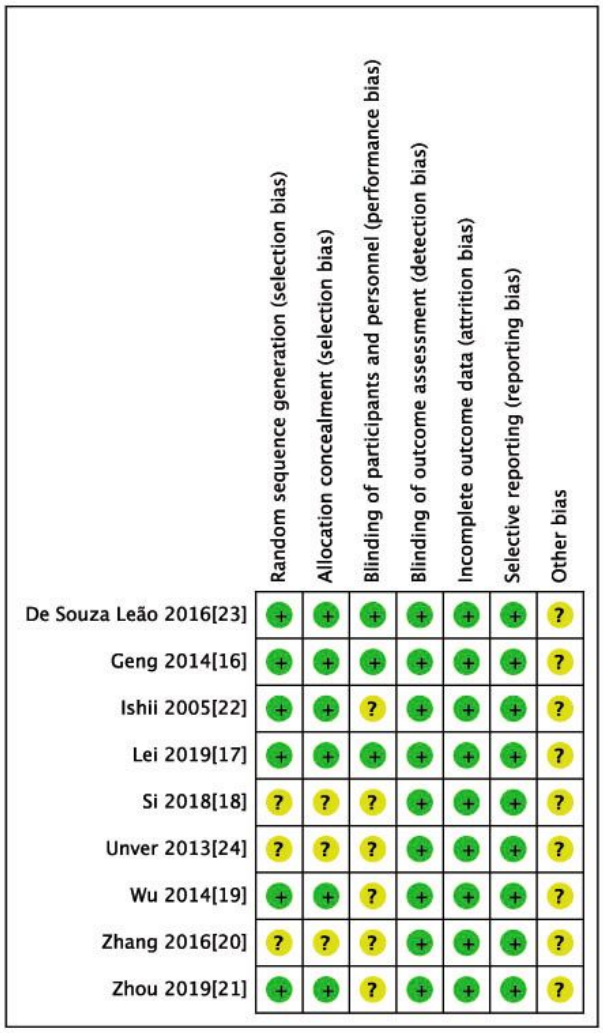


Figure 2

The risk of bias summary for RCTs +:no bias; -:bias; ?:bias unknown. The correct randomization and sufficient allocation concealment were adequately described in six studies. The blinding of outcome assessment was described in nine studies, and the blinding of participants and personnel was described in three studies. Each study retained complete outcome data and avoided selective reporting. Other potential biases of all studies can't be ignored. Therefore, we rated them as having an unclear risk of other bias. As a result, the included studies' overall quality was considered adequate (Fig. 2 and 3).

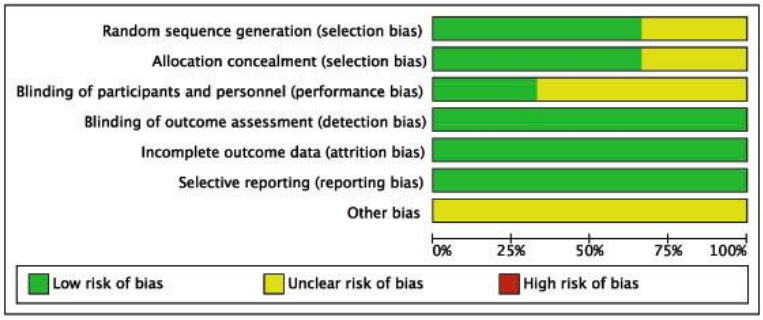


Figure 3

The risk of bias graph. The overall quality of the studies was considered adequate.

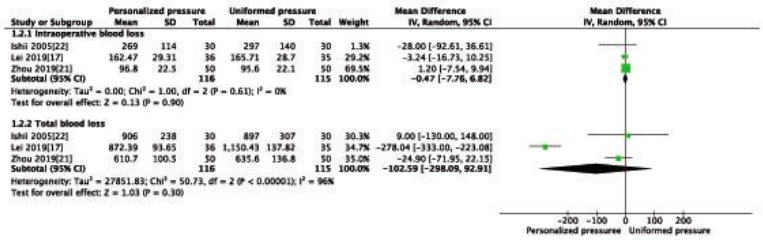


Figure 4

Pooled analysis of blood loss between the PTIP group and the UTIP group. Patients in both groups experienced similar intraoperative blood loss (MD=-0.47, 95% CI [-7.76,6.82], P=0.90) and total blood loss (MD=-102.59, 95% CI [-298.09,92.91], P=0.30).

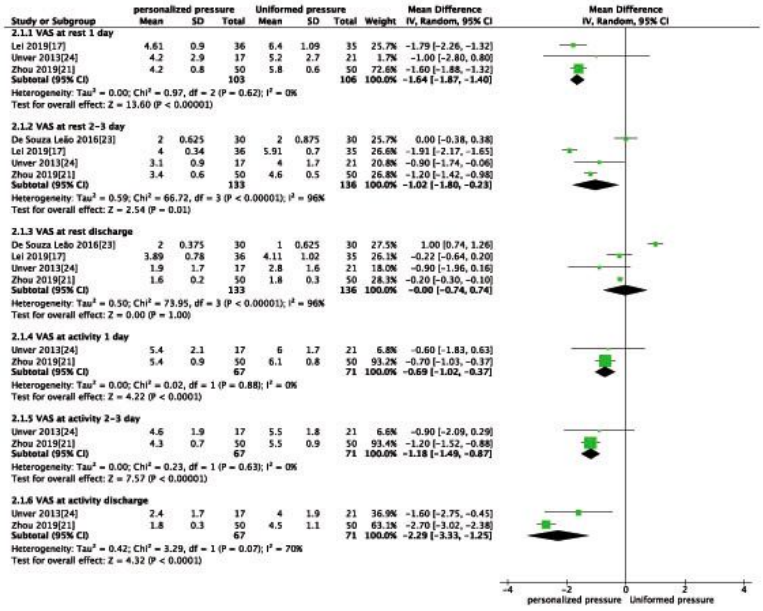


Figure 5

Pooled analysis of VAS between PTIP group and UTIP group. In personalized pressure group, there is a significantly lower VAS at rest 1day after operation(MD=-1.64, 95% CI [-1.87,-1.4], P□0.00001) ,2-3 days after operation(MD=-1.02, 95% CI [-1.8,-0.23], P=0.01) and lower VAS at activity 1day after operation(MD=-0.69, 95% CI [-1.02,-0.37], P□0.0001) ,2-3 days after operation (MD=-1.18, 95% CI [-1.49,-0.87], P□0.00001)and discharge (MD=-2.29, 95% CI [-3.33,-1.25], P□0.0001). Patients in both groups experienced similar VAS at rest when discharge from hospital (MD=-0.00, 95% CI [-0.74,0.74], P=1.0).

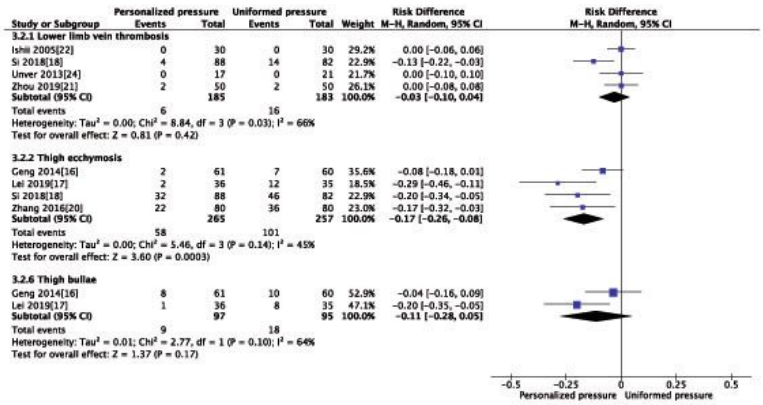


Figure 6

Pooled analysis of complication rates between PTIP group and UTIP group. Both groups experienced similar rates of lower limb vein thrombosis (MD=-0.03, 95% CI [-0.1,0.04], P=0.42) and thigh bullae (MD=-0.11, 95% CI [-0.28,0.05], P=0.17. There is a significantly lower rate of thigh ecchymosis (MD=-0.17, 95% CI [-0.26,-0.08], P=0.0003)in patients with personalized pressure group.

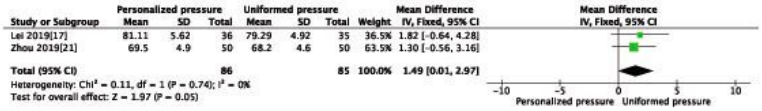


Figure 7

Pooled analysis of HSS between PTIP group and UTIP group. Both groups experienced similar HSS scores (MD=1.49, 95% CI [0.01,2.97], P=0.05).

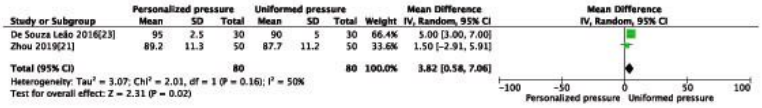


Figure 8

Pooled analysis of ROM between PTIP group and UTIP group. There is significantly better knee ROM (MD=3.82, 95% CI [0.58,7.06], P=0.02) in patients with personalized pressure group.

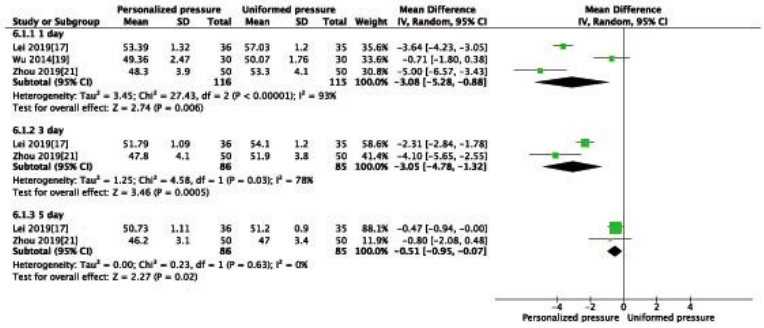


Figure 9

Pooled analysis of thigh circumference between PTIP group and UTIP group. We detected a significantly shorter thigh circumference 1 day after operation(MD=-3.08, 95% CI [-5.28,-0.88], P=0.006),3day after operation(MD=-3.05, 95% CI [-4.78,-1.32], P=0.0005) and 5 day after operation (MD=-0.51, 95% CI [-0.95,-0.07], P=0.02) in patients with personalized pressure group.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- PRISMA2009checklist.doc