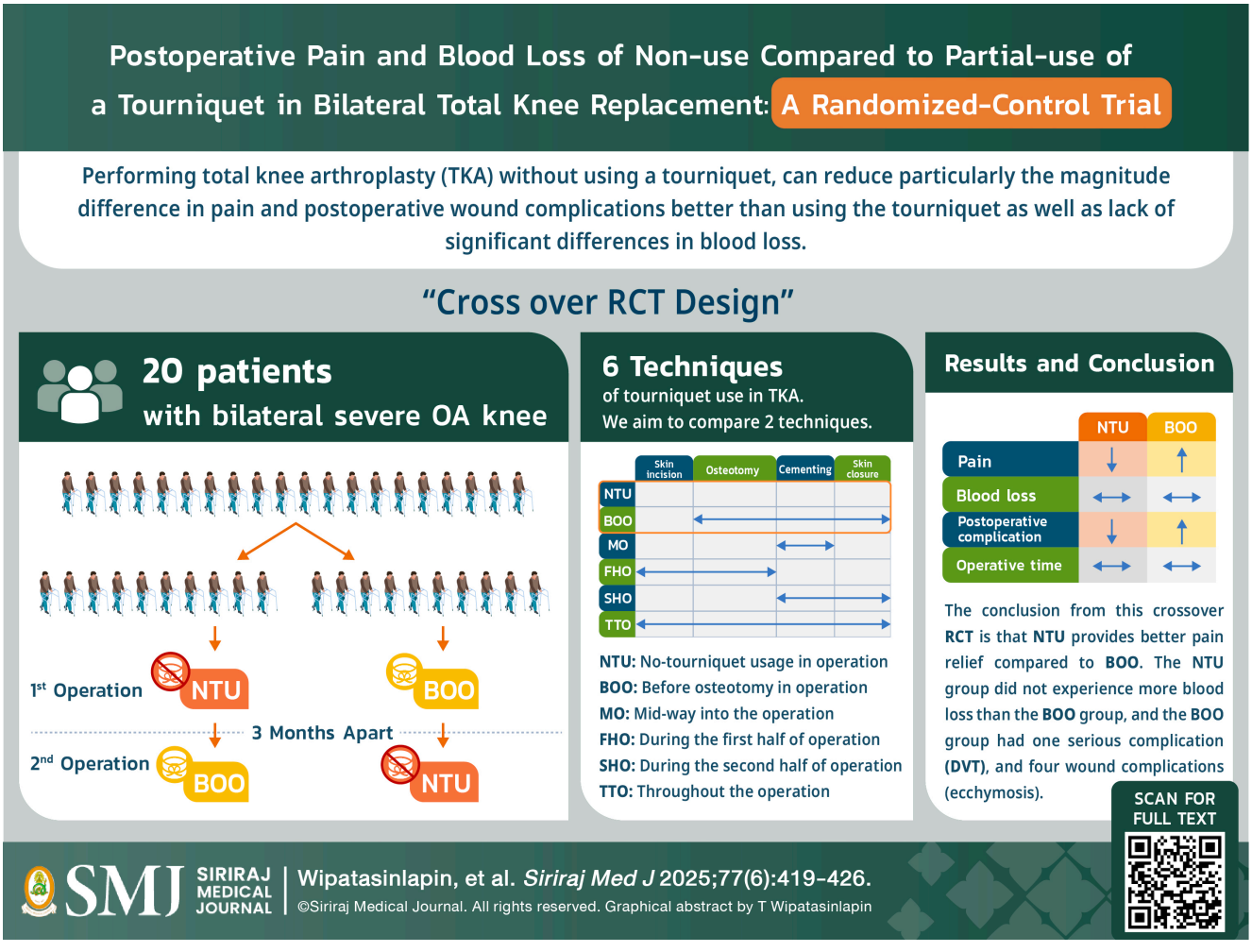
Postoperative Pain and Blood Loss of Non-use Compared to Partial-use of a Tourniquet in Bilateral Total Knee Replacement: A Randomized-Controlled Trial

Thada Wipatasinlapin, M.D.[1,*], Surapon Atiprayoon, M.D.[1], Peerawin Atiprayoon[2]
[1]Queen Savang Vadhana Memorial Hospital, Chonburi, Thailand, [2]Triam Udom Suksa School, Bangkok, Thailand.



*Corresponding author: Thada Wipatasinlapin
E-mail: fighter.thada@gmail.com
Received 11 September 2024 Revised 18 February 2025 Accepted 19 February 2025
ORCID ID: http://orcid.org/009-0002-0067-4470
https://doi.org/10.33192/smj.v77i6.271055

ABSTRACT

Objective: This study aimed to compare the effects of non-tourniquet usage (NTU) and partial-tourniquet usage (before osteotomy in operation; BOO) of a tourniquet in bilateral total knee arthroplasty (TKA) on postoperative pain and complications.

Materials and Methods: A prospective randomized controlled trial with cross-over design was designed to compare the effect of NTU vs BOO in the patients underwent bilateral TKA. The opioid consumption and pain score were primary outcomes. Blood loss, the number of wound complications, the postoperative complications and time to ambulation were secondary outcomes.

Results: NTU group showed a significantly reduction in opioid consumption (14.8 ± 8.3 mg) as compared to that of BOO group (24.6 ± 10.8 mg) in the postoperative 24 hours. The postoperative pain score was significantly lower by the first, second, third and fourth day postoperative in NTU group (3.2, 3.9, 3.5, 2.3) compared to BOO group (4.3, 5.6, 4.8, and 4.1). There was no significant difference in blood loss between the groups. Early postoperative wound ecchymosis was found in BOO group (5 knees), more than in the NTU group (1 knee) with statistical significance.

Conclusion: Performing total knee arthroplasty (TKA) without using a tourniquet, can reduce particularly the magnitude difference in pain and opioid consumption better than using the tourniquet as well as lack of significant difference in blood loss. This will allow for future clinical implications to determine that NTU may be preferable due to reduced postoperative pain and fewer postoperative wound complications.

Keywords: Total knee arthroplasty; bilateral; tourniquet; pain (Siriraj Med J 2025; 77: 419-426)

INTRODUCTION

Currently, total knee arthroplasty (TKA) has become increasingly common, due to its efficacy to improve patients' quality of life and reduce pain[1] allowing those patients with knee osteoarthritis who failed conservative treatment, to regain their ability to walk normally again. In TKA surgeries, the use of a tourniquet has been employed to aid in the reduction of blood loss during the procedure, and improving intraoperative visualization for the operating surgeon.[2-4]

However, the use of a tourniquet in TKA surgeries remains a topic of debate. There are research studies supporting its use, and some supporting operations without using a tourniquet.[5,6] While TKA with a tourniquet may reduce the operating time, it has been found to be associated with more complications. These complications include deep vein thrombosis, and an increase in occurrences of surgical-site infection, or bruising with signs of bleeding.[7] Moreover, several research studies have also found that patients - in the group using a tourniquet - experience more postoperative pain.[8] This is believed to be due to the tourniquet causing metabolic waste to accumulate in the thigh muscles, and in blood vessels around the area where it is applied.[2]

Latest evidence suggests that the most debating tourniquet-use technique is between NTU (Non-tourniquet usage) and BOO (Before Osteotomy in Operation), which involves using a tourniquet before starting the bone cutting, until wound closure. Despite numerous meta-analyses, and randomized-control trials (RCTs), there is still no conclusive evidence on the most effective, and efficient method of using a tourniquet especially between these two techniques.[9] This is because the data come from various experimental designs, with most of previous research data, being captured from studies of the outcomes of tourniquet usage in unilateral total knee arthroplasty. Hence, these studies often lack a crossover design, which could introduce confounding variables. Therefore, we designed a protocol which was a randomized-control trial with a crossover design, specifically studying the outcomes of tourniquet use in the bilateral total-knee arthroplasty of each limb in the same patient, aiming to provide clearer insights into the benefits of different tourniquet techniques.

MATERIALS AND METHODS

Inclusion and exclusion criteria

Patients diagnosed with bilateral severe knee osteoarthritis, meeting the inclusion criteria, were recruited at our institution from November 2022 to August 2024. We obtained an approval from the Institutional Review Board (IRB) of the Queen Savang Vadhana Memorial Hospital. This trial had been registered in clinical trial registry before participant enrollment (NCT06815445). The inclusion criteria were patients diagnosed with bilateral severe knee osteoarthritis, over 50 years of age. The exclusion criteria were patients having undergone previous knee surgery, being subject to uncontrolled

hypertension, coagulopathy, or recent knee sepsis, with an ASA physical status grade > 2, inability to use patient-controlled analgesia (PCA), such as communication, or cognitive issues, or those patients who were allergic to medications used in the treatment process.

Patients

20 patients (40 knees) were randomized into two groups with an allocation ratio of 1:1, determined by the various block randomization method employing a computer-generated program. Ten patients underwent NTU in the first operation and BOO in 3 months later. On the other hand, ten patients underwent BOO in the first operation and NTU in 3 months later. The two operations were spaced more than 3 months apart, as previous research indicates that this can significantly reduce morbidity and mortality, particularly concerning cardiovascular risk.[10]

On the day of the surgery, the orthopedic resident conducted the sampling method by opening a sealed envelope before the operation to determine which patients would undergo surgery without the use of a tourniquet (NTU) and which patients would have partial use of a tourniquet (BOO). Communication in the operating room would be taken place in the patient waiting area to prevent patients hearing the method of tourniquet use during that time.

Surgical technique and postoperative evaluation

The operations were performed by a single surgeon, an experienced orthopedic surgeon sub-specializing in knee arthroplasty. The surgeries involved several steps. Firstly, performance of spinal anesthesia, was carried out by an anesthesiologist. Next, was the application of an appropriately-sized, and positioned tourniquet to the patient's thigh. Then, prophylactic antibiotics were administered intravenously, being given 30 minutes prior to surgery. This was followed by the intravenous administration of ketorolac, 30 mg and Tranexamic acid 1 g, being given 30 minutes before the skin incision was made. The surgeon made a midline incision on the skin, adopting a sub-vastus approach, using an intramedullary guide wire for femur, and extramedullary guide wire for the tibia cuts. A cemented prosthesis of Zimmer Nextgen was used – as it was in every operation. A tourniquet was inflated to the systolic blood pressure (SBP), plus 100 mmHg in the leg of patients undergoing partial-use of a tourniquet (BOO), at the time of the start of the bone osteotomy until skin closure. Finally, a compressive dressing was applied, and covered with a Robert Jones bandage.

The postoperative care included an adductor canal block, with 0.25% Marcaine 20 ml, applied by an anesthesiologist in the patient recovery room to alleviate knee pain on the side operated on. Prophylactic antibiotics were administered for 48 hours post-surgery. The intravenous pain medication was given through patient-controlled analgesia (PCA), along with opioid drugs as pain relief, for the first 3 days post-surgery. The same oral pain control medications were administered for all patients. A redivac drain was removed on first postoperative day. On the second, and third postoperative days, an occlusive dressing was applied to the wound, and the patient was encouraged to ambulate with a walker.

All postoperative outcomes were performed by a single orthopedic resident. The primary outcome was the presence of postoperative pain, assessed in terms of the amount (mg) of opioid consumption, using the patient-controlled analgesia (PCA) machine at 24, 48, and 72 hours postoperative. The visual analog scale (VAS) score - ranging from 0-10 (0-2 was minimal pain, 2-4 was mild pain, 4-7 was moderate and 7-10 was severe pain) was also obtained at postoperative day 1 to day 3. 3. For the secondary outcomes, blood loss was calculated by comparing the maximal hematocrit drop between preoperative hematocrit levels and the postoperative levels on either the first or the fourth postoperative day. The time to ambulation, complications, including deep vein thrombosis (DVT), wound complications were recorded.

Sample size calculation

Calculated using STATA Version 14.0 with a power of 80% and an alpha of 0.05, the mean (SD) differences were referenced from the study by Kumar et al. (2015), (11) which examined postoperative pain using VAS for pain with different tourniquet methods in patients undergoing knee replacement surgery. This resulted in a total population of 36 knees, divided into 18 knees per group. Factoring in a 10% dropout rate, the total population needed is 40 knees, with 20 knees per group.

RESULTS

The study collected data from patients with bilateral knee osteoarthritis who underwent staged bilateral total knee arthroplasty, with at least a 3-month interval between operations. In the first group of 20 patients, the initial surgery was performed without a tourniquet (NTU), and the second surgery used a partial tourniquet (BOO) applied to the other knee. In the second group of 20 patients, the initial surgery used a partial tourniquet (BOO), while the second surgery to the other knee was

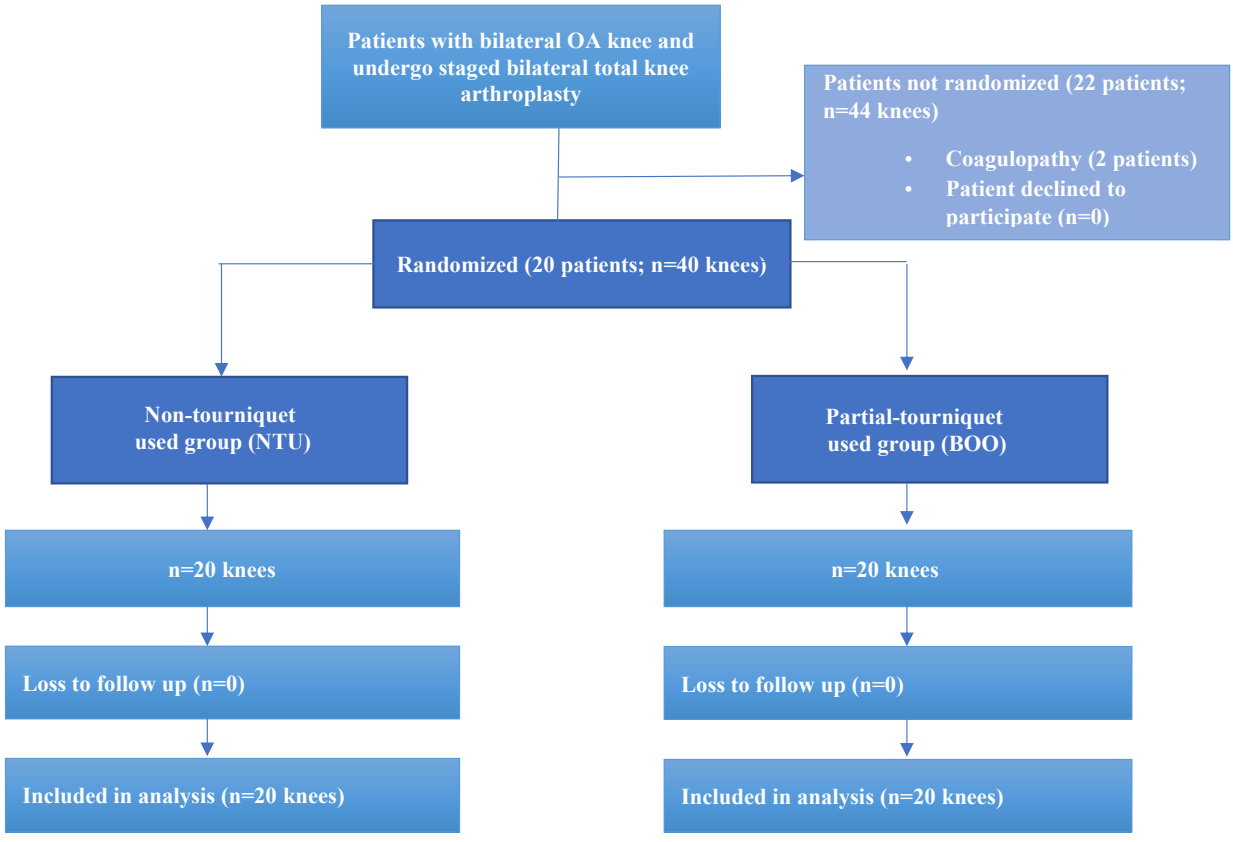


Fig 1. CONSORT Diagram

performed without tourniquet (NTU). Thus, the study analyzed a total of 20 patients (40 knees). (Table 1)

There were no cases of loss to follow-up in the study. There was 1 case with a serious complication, being Deep Vein Thrombosis (DVT) in a knee operated on with BOO with statistically significant difference, and 5 cases of wound complications in BOO group, and 1 case in NTU group with statistical significance.

The primary outcome of interest in this study was the difference in pain levels during the early postoperative period, from day 1 to day 4 before the patients were discharged, assessed in terms of the morphine consumption.

TABLE 1. Baseline characteristics.

Variable	Non-tourniquet used group first (NTU) (10 patients)	Partial-tourniquet used group (BOO) (10 patients)	P-value
Age, yr	74.3 ± 7.1	72.9 ± 8.4	0.6711
Gender; male: female	2:8	1:9	0.6200
Body mass index	27.2 ± 3.4	28.1 ± 4.5	0.6200
Preoperative hematocrit (%)	37.3 ± 3.4	38.9 ± 4.5	0.3815
Tourniquet duration (min) (for the first surgery)	0	45.6 ± 10.4	-
Operating time (for the first surgery)	93.8 ± 10.7	89.3 ± 8.5	0.3115

It was hypothesized that less pain would result in faster recovery, and earlier initiation of physical therapy, as well as greater patient satisfaction.

Results showed that the NTU group had a morphine consumption of 14.8 ± 8.3 mg in the first 24 hours after surgery, while the BOO group had a morphine consumption of 24.6 ± 10.8 mg during the same period. (Fig 2) The NTU group used significantly less morphine in the first 24 hours post-surgery with statistical significance (P value < 0.05). The following day, morphine consumption in the NTU group remained lower as shown in Table 2, but this difference was not statistical significance.

Consistent with these findings, the Visual Analog Scale (VAS) scores showed that the mean VAS score in the NTU group was 3.2, 3.9, 3.5, and 2.3 on postoperative days 1, 2, 3, and 4 respectively. In the BOO group, the mean VAS score was 4.3, 5.6, 4.8, and 4.1 on the same days. (Table 3 and Fig 3) There was a significant difference in pain scores between the NTU and BOO groups on postoperative days 1-4 (P value < 0.05).

No significant differences were found in postoperative blood loss, as assessed by decrease in the maximum hematocrit, between the two groups. (Table 4)

No significant differences were found in time to ambulation between two groups.

DISCUSSION

Until now, based on a recent systematic review, and on a meta-analysis conducted by Cao et al. in 2021, there are six techniques of using a tourniquet in total knee arthroplasty surgery.[9] The objective was to determine which tourniquet technique provides the best outcomes for patients undergoing surgery, and results in reduced postoperative complications, as well as facilitating early postoperative ambulation without pain. These techniques are:

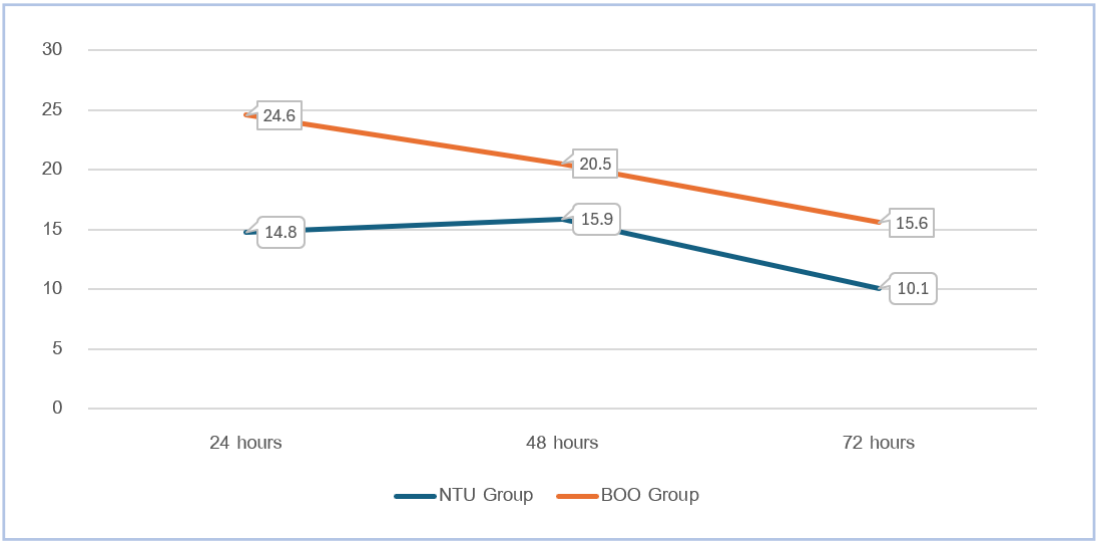


Fig 2. Morphine consumption between groups during hospital stays.

TABLE 2. Comparison of morphine consumption between groups

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
24 hours	14.8 ± 8.3	24.6 ± 10.8	3.2176	0.0026*	1.017
48 hours	15.9 ± 10.8	20.5 ± 9.6	1.4237	0.1627	0.450
72 hours	10.1 ± 5.5	15.6 ± 10.9	2.0146	0.0511	0.637

TABLE 3. Comparison of VAS for pain between groups.

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
POD 1	3.2 ± 1.8	4.3 ± 1.6	2.0426	0.0481*	0.645
POD 2	3.9 ± 1.5	5.6 ± 1.1	4.0872	0.0002*	1.292
POD 3	3.5 ± 1.6	4.8 ± 1.2	2.9069	0.0061*	0.919
POD 4	2.3 ± 1.1	4.1 ± 1.1	5.1746	0.0001*	1.636

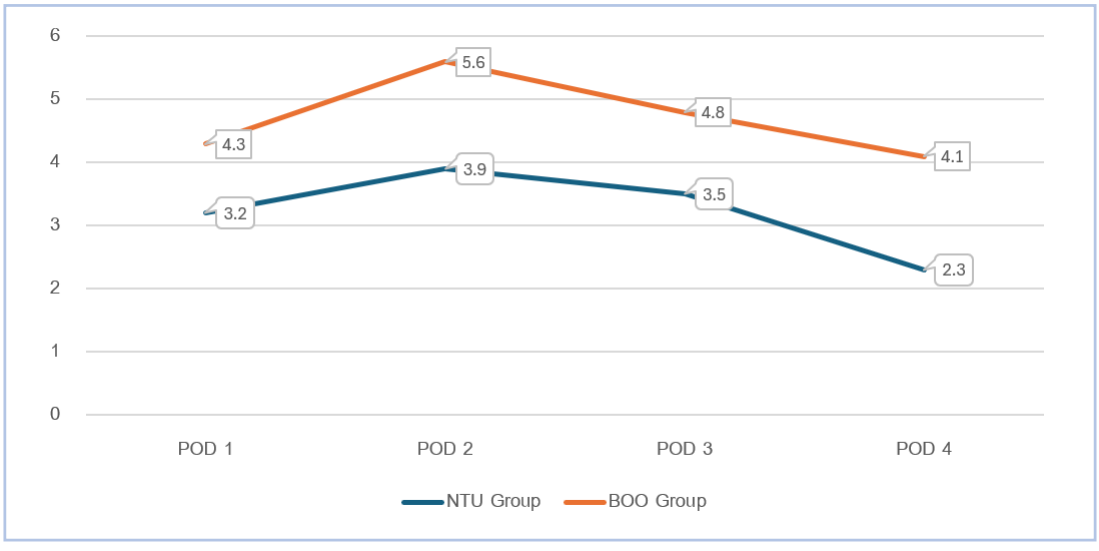


Fig 3. VAS for pain between groups during hospital stays

TABLE 4. Comparison of blood loss between groups.

Time	Non-tourniquet used group (NTU) (n=20)	Partial-tourniquet used group (BOO) (n=20)	t	P (two-tailed)	Effect size (Cohen's d)
Preop	37.3 ± 3.4	38.9 ± 4.5	1.4030	0.1687	0.401
POD 1	32.7 ± 4.1	34.4 ± 3.3	1.6172	0.1141	0.456
POD 4	31.8 ± 3.2	32.8 ± 2.5	1.1013	0.2777	0.348
Maximum drop	7.2 ± 2.3	6.9 ± 3.3	0.3335	0.7406	0.105

1) Non-tourniquet usage (NTU): No tourniquet is used throughout the surgery.
2) Mid-way into the operation (MO): Tourniquet is used only during the period of cement implantation.
3) During the first half of operation (FHO): Tourniquet is used from skin incision until bone osteotomy is finished.
4) During the second half of operation (SHO): Tourniquet is used from cement implantation until wound closure is finished.
5) Before osteotomy in operation (BOO): Tourniquet is used from bone osteotomy until wound closure is finished.
6) Throughout the operation (TTO): Tourniquet is used from skin incision until wound closure is finished.

This recent systematic review and meta-analysis suggests that the best recommended technique is BOO (Before Osteotomy in Operation), which involves using a tourniquet before starting the bone cutting, until wound closure. This technique has been found to be the most effective in reducing blood loss, shortening the duration of surgery, and minimizing postoperative complications, based on comparative analysis.[9]

Despite the numerous meta-analyses and randomized-control trials (RCTs) conducted, a definitive conclusion on the most beneficial and effective use of tourniquets remains inconclusive.[9,12-14] This is because the available data comes from studies with various methodologies, including many that have focused on the effect of tourniquets in unilateral total knee arthroplasty (TKA), rather than crossover studies. Such studies may be prone to confounding factors. Therefore, to better understand the benefits, research needs to be conducted using randomized-control trials with a crossover design, specifically examining the effect of tourniquets in patients undergoing bilateral total knee arthroplasty (TKA).

Currently, there are only three RCTs that have studied the effect of tourniquets in bilateral TKA. In 2015, Kumar et al. compared NTU with TTO, and found that patients in the NTU group experienced significantly less postoperative pain compared to those in the TTO group.[11] Then, in 2016, Wang et al. compared FHO with MO, and found that the MO group had significantly less postoperative pain and blood loss compared to the FHO group, leading to better recovery, and physical therapy outcomes.[3] Most recently, in 2017, Liu et al. conducted another study comparing NTU with TTO, and again found that the NTU group had experienced significantly less postoperative pain compared to the TTO group.[8]

However, none of these studies have compared NTU with BOO to determine which method is more effective, and has better outcomes. This is the rationale for the current study, which aims to compare non-use of the tourniquet (NTU) with partial use of the tourniquet (BOO) in the context of bilateral TKA performed on the same patient with at least a 3-month interval between surgeries.

Therefore, the conclusion from this crossover RCT is that NTU provides better pain relief compared to BOO. The NTU group did not experience more blood loss than the BOO group, and the BOO group had one serious complication (DVT), and four wound complications (ecchymosis). Thus, this study supports that performing total knee arthroplasty without a tourniquet is more effective than other methods. The strength of this research lies in its use of a crossover RCT design to minimize confounding factors, and in its objective measurement of pain through morphine consumption, in milligrams.

A limitation of this study is the sample size, which could be increased. Future research could focus on comparing the most effective tourniquet methods by conducting crossover design studies in bilateral total knee arthroplasty. Another limitation was the crossover design itself, the study might have inherent risks of carry-over effects, especially related to differences in recovery post-first surgery that could influence the outcomes of the second surgery.

CONCLUSION

Performing total knee arthroplasty (TKA) without using a tourniquet, can reduce particularly the magnitude of the difference in pain and opioid consumption better than using the tourniquet as well as lack of significant differences in blood loss. This will allow for future clinical implications to determine that NTU may be preferable due to reduced postoperative pain and fewer postoperative wound complications.

Data Availability Statement

Data are available on reasonable request. Data may be obtained from a third party and are not publicly available. Data are available upon request to the authors.

ACKNOWLEDGEMENTS

I would like to thank Queen Savang Vadhana Memorial Hospital Institute for providing the necessary resources and funding for this project. Special thanks to my colleagues, Varissara Chatyanan and Chalathorn Kulthonchalanan, for their assistance with data collection and analysis.

DECLARATIONS

Grants and Funding Information

Queen Savang Vadhana Memorial Hospital Institute

Conflict of Interest

The authors declare no conflicts of interest.

Registration Number of Clinical Trial

NCT06815445

Author Contributions

Conceptualization and methodology, T.W., and S.A. ; Investigation, T.W. ; Formal analysis, T.W., and P.A.; Visualization and writing – original draft, T.W. ; Writing – review and editing, T.W., and S.A. ; Funding acquisition, T.W., and S.A. ; Supervision, S.A. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

Not applicable .

REFERENCES

1. Luansritisakul C. Quality of Life after Total Knee Replacement at Siriraj Hospital, Thailand. Siriraj Med J. 2016;68(2):72-78.
2. Vandenbussche E, Duranthon LD, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. Int Orthop. 2002;26(5):306-9.
3. Ozkunt O, Sariyilmaz K, Gemalmaz HC, Dikici F. The effect of tourniquet usage on cement penetration in total knee arthroplasty: a prospective randomized study of 3 methods. Medicine (Baltimore). 2018;97(4):e9668.
4. Arthur JR, Spangehl MJ. Tourniquet use in total knee arthroplasty. J Knee Surg. 2019;32(08):719-29.
5. Alexandersson M, Wang EY, Eriksson S. A small difference in recovery between total knee arthroplasty with and without tourniquet use the first 3 months after surgery: a randomized controlled study. Knee Surg Sports Traumatol Arthrosc. 2019; 27(4):1035-42.
6. Jawhar A, Stetzelberger V, Kollowa K, Obertacke U. Tourniquet application does not affect the periprosthetic bone cement penetration in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2019;27:2071-81.
7. Matar HE, Platt SR, Gollish JD, Cameron HU. Overview of randomized controlled trials in total knee arthroplasty (47,675 patients): what have we learnt? J Arthroplasty. 2020;35(6):1729-36.e1.
8. Liu Y, Si H, Zeng Y, Li M, Xie H, Shen B. More pain and slower functional recovery when a tourniquet is used during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2020;28: 1842-60.
9. Cao Z, Guo J, Li Q, Wu J, Li Y. Comparison of efficacy and safety of different tourniquet applications in total knee arthroplasty: a network meta-analysis of randomized controlled trials. Ann Med. 2021;53(1):1816-26.
10. Wang KY, LaVelle MJ, Gazgalis A, Bender JM, Geller JA, Neuwirth AL, Cooper HJ, Shah RP. Bilateral total knee arthroplasty: current concepts review. JBJS Rev. 2023;11(1):e22.
11. Kumar K, Railton C, Tawfic Q. Tourniquet application during anesthesia: "What we need to know?" J Anaesthesiol Clin Pharmacol. 2016;32(4):424-30.
12. Tai TW, Lin CJ, Jou IM, Chang CW, Lai KA, Yang CY. Tourniquet use in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2011;19:1121-30.
13. Alcelik I, Pollock RD, Sukeik M, Bettany-Saltikov J, Armstrong PM, Fismer P. A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty. 2012;27(3):331-40.
14. Deering EM, Hu SY, Abdulkarim A. Does tourniquet use in TKA increase postoperative pain? A systematic review and meta-analysis. Clin Orthop Relat Res. 2019;477(3):547-58.