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Research Paper

Impact of Tourniquet on Blood Loss and Postoperative Recovery in Total Knee Arthroplasty: A Randomized Clinical Trial

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ABSTRACT

Background: Total knee arthroplasty (TKA) is an effective surgical procedure for alleviating pain and improving function in patients with severe knee osteoarthritis. However, significant intraoperative blood loss is a common concern, often necessitating blood transfusions and increasing the risk of complications. A tourniquet during TKA is a widely accepted technique to reduce blood loss and improve implant fixation, but it may lead to postoperative pain and restricted range of motion (ROM).

Objectives: This randomized clinical trial aimed to compare intraoperative blood loss, postoperative ROM, and pain in patients undergoing TKA with and without a tourniquet.

Methods: A total of 34 patients were randomized into two groups: 18 patients in the tourniquet group (TG) and 16 in the non-tourniquet group (NTG). Intraoperative blood loss, postoperative hemoglobin levels, ROM, thigh pain, and straight leg raise (SLR) were measured at multiple intervals postoperatively.

Results: The results showed that the TG group had significantly lower intraoperative blood loss (236.11 mL vs 531.25 mL, P<0.001) and higher postoperative hemoglobin levels than the NTG group. However, the TG group experienced significantly lower ROM on the first and second postoperative days (P<0.001) and reported greater thigh pain. By six months postoperatively, the two groups had no significant difference in ROM.

Conclusion: Using a tourniquet in TKA significantly reduces intraoperative blood loss but is associated with increased immediate postoperative pain and reduced early ROM. However, these adverse effects do not persist long-term. Individualized patient care and strategies to optimize tourniquet use are recommended to balance these outcomes.

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Introduction

Total knee arthroplasty (TKA) is a highly effective surgical intervention for improving the quality of life, range of motion (ROM), and overall function of the knee joint in patients suffering from severe knee osteoarthritis [1]. However, significant blood loss during and after TKA is a primary concern, often necessitating blood transfusions and increasing the risk of related complications [2]. Studies have reported that the average blood loss during TKA ranges from 1000 to 2000 mL, with 10% to 38% of patients requiring a transfusion [3].

Various strategies have been employed to minimize blood loss and the need for transfusions, including hypotensive anesthesia, autologous blood transfusion, bone cement, pharmacological agents such as tranexamic acid, and mechanical methods like tourniquet application [4, 5]. The use of a tourniquet is particularly common in TKA, as it facilitates a bloodless surgical field and improves cement fixation, which may enhance implant stability and longevity [6]. Despite these advantages, the use of a tourniquet is associated with several drawbacks, such as delayed bleeding, increased postoperative pain, reduced early postoperative ROM, and a higher risk of complications like deep vein thrombosis [7, 8].

The debate on using a tourniquet in TKA has remained unsolved due to conflicting evidence regarding its benefits and risks. Some studies suggest that while a tourniquet effectively reduces intraoperative blood loss, it may adversely affect early rehabilitation outcomes, particularly regarding pain and knee function [9, 10]. Other studies have found that the long-term outcomes of ROM and knee function are not significantly different between patients undergoing TKA with or without a tourniquet [11, 12]. Given the contrasting findings, it is crucial to investigate further the impact of tourniquet use on both bleeding and ROM to provide clearer guidance on its use in TKA.

This study aims to compare the amount of blood loss and the postoperative ROM in patients undergoing TKA with and without a tourniquet. By understanding the short- and long-term effects of tourniquet application, this research seeks to contribute to the ongoing debate and aid in optimizing surgical strategies for TKA.

Methods

This is a single-blinded, randomized clinical trial designed to investigate the effects of wearing a tourniquet versus not during TKA at Shafa Yahyaeian Orthopedic Hospital, Iran. The primary objective is to assess differences in blood loss and postoperative ROM of the knee between the two groups.

Eligible participants were adults scheduled for elective primary TKA. The exclusion criteria included patients with coagulopathy, rheumatoid arthritis, neurologic matters that lead to a decrease in the force of quadriceps femoris muscle, knee flexion <60° or >15° of varus or valgus deformity before the surgery, history of antiplatelet, anti-coagulative, or opioid consumption, and previous knee surgery. All participants provided written informed consent before enrollment.

Participants were randomized into the tourniquet group (TG) and the non-tourniquet group (NTG). All patients underwent spinal anesthesia. In the TG group, a pneumatic tourniquet was applied to the proximal thigh. After bandaging the leg and completely draining the blood, the tourniquet was inflated to 150-200 mm Hg above the systolic blood pressure, and the surgery was performed with a midline incision. In patients with a tourniquet, after complete bone cutting, the tourniquet was turned off for 15 minutes (during cementing, a stage of blood vessel catheterization was performed). The tourniquet was then re-inflated. The area was thoroughly cleaned and dried. Complete blood loss was calculated for all patients. Hemoglobin levels were checked before and 6 hours after surgery and compared with preoperative levels. Twenty-four hours after surgery, all patients' straight leg raises (SLR) were checked to assess pain intensity and patient cooperation. Celecoxib was prescribed for severe pain.

This study was single-blinded, meaning the participants were unaware of their group assignment. Surgeons and operating room staff were not blinded due to the nature of the intervention. The primary outcome measure was the ROM, measured preoperatively and one day, two days, one week, two months, and six months postoperatively. Secondary outcome measures included an SLR test, thigh pain one day postoperatively, and intraoperative blood loss.

A total of 34 participants were enrolled in the study, with 18 participants in the TG and 16 in the NTG. The sample size was calculated based on a power analysis to detect a clinically significant difference in the rate of bleeding with an alpha of 0.05 and a power of 0.8.

Participants were randomized using a computer-generated random sequence in four blocks to ensure equal allocation. Allocation concealment was maintained us-

ing sealed, opaque envelopes opened just before the intervention.

Trained orthopedic surgery assistants collected data. Postoperative ROM was recorded at specified intervals, and blood samples were taken preoperatively and 4 consecutive days postoperatively to measure hemoglobin levels.

Statistical analysis was performed using SPSS software, version 22. Qualitative data were addressed using frequency and percentage, and the quantitative data were measured using Mean±SD. Continuous variables were compared using the independent t-test, and categorical variables were compared using the chi-square test. P<0.05 was considered statistically significant.

Results

A total of 34 participants were included in the study, with 18 in the TG and 16 in the NTG. The participants comprised 9 males (26.5%) and 25 females (73.5%), with no significant differences in baseline characteristics between the groups.

Intraoperative blood loss

The mean intraoperative blood loss was significantly lower in the TG compared to the NTG. The TG had an average blood loss of 236.11 cc (±93.63), while the NTG had an average of 531.25±179.7 cc, a dierence that was statistically significant (P<0.001). This demonstrates that the use of a tourniquet effectively reduces blood loss during knee joint replacement surgery (Table 1).

Hemoglobin levels

Postoperative hemoglobin levels were measured on days 1 through 4. On the first postoperative day, the TG had a mean hemoglobin level of 13.21 g/dL (±1.10), while the NTG had a significantly lower mean of 11.03 g/dL (±2.98) (P=0.007). This trend continued over the subsequent days, with the TG consistently showing higher hemoglobin levels compared to the NTG, indicating less blood loss in the TG. For instance, on day 4, the TG had a mean hemoglobin level of 11.39 g/dL (±1.52) vs 9.85 g/dL (±1.35) in the NTG (P=0.008) (Table 1).

ROM

Postoperative ROM was assessed at arious intervals, with significant differences observed between the groups. On the first postoperative day, the TG had a mean ROM of 23.89 degrees (±9.79) compared to 45.00 degrees (±5.16) in the NTG (P<0.001) (Table 1). By the second day, the mean ROM in the TG increased to 46.67 degrees (±9.08), while the NTG achieved 64.38 degrees (±6.29) (P<0.001).However, by six months, the ROM in both groups was similar, with the TG achieving 113.82 degrees (±5.51) and the NTG 101.76 degrees (±6.26), with no significant difference (P=0.552) (Table 1).

Intraoperative blood loss

Test and thigh pain

The SLR test results one day postoperatively showed significant differences between the two groups. In the TG, 100% of patients rated their SLR as either "very bad" or "bad," whereas in the NTG, 80% rated it as "good" or "very good" (P<0.001) (Table 2). Regarding thigh pain, all patients in the TG reported moderate to

Table 1. Comparing intraoperative blood loss, hemoglobin levels, and ROM

Outcomes	Mean±SD		P
	TG (n=18)	NTG (n=16)	
Intraoperative blood loss (mL)	236.11±93.63	531.25±179.7	<0.001
Postoperative hemoglobin (day 1, g/dL)	13.21±1.1	11.03±2.98	0.007
Postoperative hemoglobin (day 4, g/dL)	11.39±1.52	9.85±1.35	0.008
ROM (day 1, degrees)	23.89±9.79	45.00±5.16	<0.001
ROM (day 2, degrees)	46.67±9.08	64.38±6.29	<0.001
ROM (6 months, degrees)	113.82±5.51	101.76±6.26	0.552

Table 2. SLR outcomes

SLR Rating	%		P
	TG (n=18)	NTG (n=16)	
Very bad (<45°)	44.4	0	<0.001
Bad (45-60°)	44.4	6.25	
Good (60-75°)	11.2	50	
Very good (75-90°)	0	43.75	

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Table 3. Thigh pain postoperatively

Thigh Pain Severity	TG (n=18)	NTG (n=16)	P
Very mild	0	81.25	<0.001
Mild	5.88	18.75	
Moderate	11.76	0	
Severe	29.41	0	
Very severe	52.94	0	

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severe pain, with 53% rating it as "severe" or "very severe." Conversely, the majority of NTG patients (94%) reported very mild or mild pain (P<0.001) (Table 3).

Hemoglobin levels

Postoperative hemoglobin levels were measured on days 1 through 4. On the first postoperative day, the TG group had a mean hemoglobin level of 13.21±1.10 g/dL, while the NTG group had a significantly lower mean of 11.03±2.98 g/dL (P=0.007). This trend continued over the subsequent days, with the TG group consistently showing higher hemoglobin levels than the NTG, indicating less blood loss in the TG. For instance, on day 4, the TG group had a mean hemoglobin level of 11.39±1.52 g/dL vs 9.85±1.35 g/dL in the NTG group (P=0.008).

ROM

Postoperative ROM was assessed at various intervals, with significant differences observed between the groups. On the first postoperative day, the TG group had a mean ROM of 23.89±9.79 degrees compared to 45±5.16 degrees in the NTG group (P<0.001). By the second day, the mean ROM in the TG group increased to 46.67±9.08 degrees, while the NTG group achieved 64.38±6.29 degrees (P<0.001). However, by six months, the ROM in both groups was similar, with the TG group achieving 113.82±5.51 degrees and the NTG group 101.76±6.26 degrees, with no significant difference (P=0.552).

SLR test and thigh pain

One day postoperatively, the SLR test results showed significant differences between the two groups. In the TG, 100% of patients rated their SLR as either “very bad” or “bad”, whereas in the NTG, 80% rated it as “good” or “very good” (P<0.001). Regarding thigh pain, all patients in the TG reported moderate to severe pain, with 53% rating it as “severe” or “very severe”. Conversely, the majority of NTG patients (94%) reported very mild or mild pain (P<0.001).

Discussion

This study aimed to evaluate the impact of tourniquet use on blood loss and ROM in patients undergoing TKA. The findings indicate that applying a tourniquet significantly reduces intraoperative blood loss and helps maintain higher postoperative hemoglobin levels. Still, it is associated with increased immediate postoperative thigh pain and decreased ROM. However, no significant difference in ROM was observed between the groups at six months.

Blood loss and hemoglobin levels

The significant reduction in intraoperative blood loss observed in the TG compared to the NTG is consistent with previous studies. Several meta-analyses and randomized controlled trials have reported that tourniquet application during TKA effectively minimizes intraoperative blood loss due to reduced arterial inflow to the surgical site [13, 14]. Additionally, maintaining higher hemoglobin levels postoperatively, as seen in our study, aligns with findings from other studies where tourniquet use minimized the need for blood transfusion and reduced the risk of transfusion-related complications [15]. However, the risk of delayed bleeding upon tourniquet release remains a concern, suggesting a careful balance is needed in its application to optimize patient outcomes.

ROM and pain

Despite the benefits of blood loss, our study found that the TG experienced significantly reduced ROM in the immediate postoperative period. This finding corroborates with research indicating that the use of a tourniquet can lead to early postoperative complications, such as muscle ischemia, nerve compression, and increased thigh pain, all of which can contribute to reduced ROM and delayed rehabilitation [16]. The muscle ischemia caused by prolonged tourniquet inflation may result in increased muscle enzyme markers associated with greater postoperative pain and swelling, potentially explaining our study's early reduction in ROM [17]. Furthermore, the compression effects of the tourniquet on soft tissues can cause a direct injury, contributing to pain and stiffness [18].

Interestingly, our study found that by six months postoperatively, the difference between the TG and NTG groups in ROM was no longer significant, indicating that the initial disadvantages of tourniquet use in terms of ROM may not have a long-term impact. This result aligns with other studies demonstrating that early postoperative deficits in ROM associated with tourniquet use tend to resolve with time, and by 6 to 12 months postoperatively, there is typically no significant difference in ROM outcomes between those who had a tourniquet and those who did not [19].

Clinical implications

The use of a tourniquet in TKA remains a topic of debate, particularly regarding its effect on early postoperative recovery and complications. The findings from our study suggest that while tourniquet use effectively reduces blood loss, it may contribute to increased early postoperative pain and delayed functional recovery due to restricted ROM. Thus, the decision to use a tourniquet should be individualized based on the patient's risk factors for bleeding and postoperative complications, the surgeon's experience, and the specific clinical setting. Additionally, techniques to minimize tourniquet time and pressure, such as intermittent deflation or lower inflation pressures, may mitigate some adverse effects while preserving the benefits [20].

Conclusion

The findings of this study suggest that while the use of a tourniquet in TKA significantly reduces intraoperative blood loss and the need for blood transfusion, it is associated with increased thigh pain and reduced ROM in the immediate postoperative period. However, these adverse effects do not persist for a long time, as no significant differences in ROM were observed six months postoperatively. Further studies are recommended to explore strategies to mitigate the short-term adverse effects of tourniquet use while preserving its benefits.

Further research is needed to explore alternative strategies that balance the benefits of reduced blood loss with the depreciation of adverse effects on ROM and pain. Potential investigation areas include pharmacologic agents like tranexamic acid in conjunction with lower tourniquet pressures or shorter application times to reduce bleeding without compromising muscle and nerve function. Additionally, the role of patient-specific factors, such as baseline muscle strength and vascular health, in influencing the outcomes of tourniquet use warrants further study to refine patient selection criteria.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (Code: IR.IUMS.FMD.REC.1399.194)

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This paper was extracted from the medical residency thesis of Seyda Bahamin, approved by the Department of Orthopedics, School of Medicine Iran University of Medical Sciences, Tehran, Iran.

Authors' contributions

Conceptualization and supervision: Abolfazl Bagheri-Fard, Mahmoud Jabalameli, and Hooman Yahyazadeh; Methodology: Seyda Bahamin, Mohammad Hasan Nozaeim; Data collection, analysis, investigation and writing: All authors.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Steinhaus ME, Christ AB, Cross MB. Total knee arthroplasty for knee osteoarthritis: Support for a foregone conclusion? HSS J. 2017; 13(2):207-10. [DOI:10.1007/s11420-017-9558-4] [PMID]

[2] Wu EB, Hung KC, Juang SE, Chin JC, Lu HF, Ko JY. Are risk factors for postoperative significant hemorrhage following total knee arthroplasty potentially modifiable? A retrospective cohort study. J Pers Med. 2022; 12(3):434. [DOI:10.3390/jpm12030434] [PMID]

[3] Liu Y, Shan D, Tian P, Li ZJ, Xu GJ, Fu X. Peri-articular injection of tranexamic acid reduce blood loss and transfusion requirement during total knee arthroplasty: A meta-analysis. geriatr orthop surg rehabil. 2022; 13:21514593221101264. [DOI:10.1177/21514593221101264] [PMID]

[4] Alshryda S, Sarda P, Sukeik M, Nargol A, Blenkinsopp J, Mason JM. Tranexamic acid in total knee replacement: A systematic review and meta-analysis. J Bone Joint Surg Br. 2011; 93(12):1577-85. [DOI:10.1302/0301-620X.93B12.26989]

[5] Levine BR, Haughom B, Strong B, Hellman M, Frank RM. Blood management strategies for total knee arthroplasty. JAAOS. 2014; 22(6):361-71. [DOI:10.5435/JAAOS-22-06-361]

[6] Hegde V, Bracey DN, Johnson RM, Dennis DA, Jennings JM. Tourniquet use improves cement penetration and reduces radiolucent line progression at 5 years after total knee arthroplasty. J Arthroplasty. 2021; 36(7S):S209-14. [DOI:10.1016/j.arth.2020.12.048] [PMID]

[7] Pyati S, Cobert J, Jabre JF, Kaye AD, Diaz JH, Raghunathan K. Effects of tourniquets in the development of pain states: A novel clinical pilot study and review of utilization of tissue oximetry to measure neural ischemia. Curr Pain Headache Rep. 2020; 24(6):25. [DOI:10.1007/s11916-020-00855-x] [PMID]

[8] Xie J, Yu H, Wang F, Jing J, Li J. A comparison of thrombosis in total knee arthroplasty with and without a tourniquet: A meta-analysis of randomized controlled trials. J Orthop Surg Res. 2021; 16(1):408. [DOI:10.1186/s13018-021-02366-w] [PMID]

[9] Zhao HY, Yeersheng R, Kang XW, Xia YY, Kang PD, Wang WJ. The effect of tourniquet uses on total blood loss, early function, and pain after primary total knee arthroplasty: A prospective, randomized controlled trial. Bone Joint Res. 2020; 9(6):322-32. [DOI:10.1302/2046-3758.96.BJR-2019-0180.R3] [PMID]

[10] Beckers G, Mazy D, Manche E, Geulette B. Impact of tourniquet use in total knee arthroplasty on functional recovery and postoperative pain: A prospective study. Arch Orthop Trauma Surg. 2024; 144(3):1361-7. [DOI:10.1007/s00402-023-05158-5] [PMID]

[11] Pavão DM, Pires eAlbuquerque RS, de Faria JLR, Sampaio YD, de Sousa EB, Fogagnolo F. Optimized tourniquet use in primary total knee arthroplasty: A comparative, prospective, and randomized study. J Arthroplasty. 2023; 38(4):685-90. [DOI:10.1016/j.arth.2022.10.026] [PMID]

[12] Zak SG, Yeroushalmi D, Long WJ, Meftah M, Schnaser E, Schwarzkopf R. Does the use of a tourniquet influence outcomes in total knee arthroplasty: A randomized controlled trial. J Arthroplasty. 2021; 36(7):2492-6. [DOI:10.1016/j.arth.2021.02.068] [PMID]

[13] 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(6):1842-60. [DOI:10.1007/s00167-019-05617-w]

[14] Xu X, Wang C, Song Q, Mou Z, Dong Y. Tourniquet use benefits to reduce intraoperative blood loss in patients receiving total knee arthroplasty for osteoarthritis: An updated meta-analysis with trial sequential analysis. J Orthop Surg. 2023; 31(2):10225536231191607. [DOI:10.1177/10225536231191607] [PMID]

[15] Barros MFFH, Ribeiro EJC, Dias RG. Blood level changes in total knee arthroplasty with and without a tourniquet. Rev Bras Ortop. 2017; 52(6):725-30. [DOI:10.1016/j.rboe.2017.10.001] [PMID]

[16] Zhao J, Dong X, Zhang Z, Gao Q, Zhang Y, Song J, et al. Association of use of tourniquets during total knee arthroplasty in the elderly patients with post-operative pain and return to function. Front Public Health. 2022; 10:825408. [DOI:10.3389/fpubh.2022.825408] [PMID]

[17] Ostman B, Michaelsson K, Rahme H, Hillered L. Tourniquet-induced ischemia and reperfusion in human skeletal muscle. Clin Orthop Relat Res. 2004; (418):260-5. [DOI:10.1097/00003086-200401000-00045] [PMID]

[18] Masri BA, Eisen A, Duncan CP, McEwen JA. Tourniquet-induced nerve compression injuries are caused by high pressure levels and gradients - a review of the evidence to guide safe surgical, pre-hospital and blood flow restriction usage. BMC Biomed Eng. 2020; 2:7. [DOI:10.1186/s42490-020-00041-5] [PMID]

[19] Goel R, Rondon AJ, Sydnor K, Blevins K, O'Malley M, Purtill JJ, et al. Tourniquet use does not affect functional outcomes or pain after total knee arthroplasty: A prospective, double-blinded, randomized controlled trial. J Bone Joint Surg Am. 2019; 101(20):1821-8. [DOI:10.2106/JBJS.19.00146] [PMID]

[20] Kim TK, Bamne AB, Sim JA, Park JH, Na YG. Is lower tourniquet pressure during total knee arthroplasty effective? A prospective randomized controlled trial. BMC Musculoskelet Disord. 2019; 20(1):275. [DOI:10.1186/s12891-019-2636-7] [PMID]