Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

Evaluating the Impact of Tourniquet Use on Outcomes in Total Knee Arthroplasty: A Comparative Study

Dr. Radhesh K.R., Dr. Akber Ikram Ahmed, Dr. Nikil Das Bhat, Dr. Sachin Shettappanavar

MBBS, MS (Orthopedics) Shridevi Institute of Medical Sciences and Research Hospital,Sira Road, Tumkur - 572106, Karnataka, India
MBBS, MS (Orthopedics) Shridevi Institute of Medical Sciences and Research Hospital,Sira Road, Tumkur - 572106, Karnataka, India
MBBS, MS (Orthopedics) Shridevi Institute of Medical Sciences and Research Hospital,Sira Road, Tumkur - 572106, Karnataka, India
MBBS, MS (Orthopedics), Postgraduate Trainee, Shridevi Institute of Medical Sciences and Research Hospital,Sira Road, Tumkur - 572106, Karnataka, India
Corresponding Author: Dr. Sachin Shettappanavar

Abstract

Objective: To investigate the impact of tourniquet use in total knee replacement (TKR) surgery on pain, blood loss, range of motion, and complications.

Methods: This prospective, randomized controlled trial included 40 patients undergoing TKR, divided into two groups: tourniquet (Group T) and non-tourniquet (Group WT). Pain was assessed using the Simplified Verbal Scale (SVS). Post-operative drain collection and range of motion at one week were measured.

Results: Group T reported significantly higher SVS scores on the first day post-surgery (2.65 vs. 2.2, p=0.0032). However, the difference was not observed on days 2 and 3. Group T also exhibited significantly higher drain collection (1009 ml vs. 628 ml, p<0.0001) and lower range of motion (70.5° vs. 80°, p=0.0099) compared to Group WT. No significant difference in DVT or paresis incidence was observed.

Conclusion: Tourniquet use in TKR was associated with increased early pain, bleeding, and limited range of motion, despite providing a bloodless field. Surgeons should carefully consider the potential benefits and drawbacks before utilizing tourniquets, tailoring their approach to individual patient characteristics. Future research should focus on optimizing tourniquet use and exploring alternative bloodless field techniques.

Keywords: Tourniquet, Total Knee Replacement, Pain, Blood Loss, Range of Motion, Complications

Introduction

Total knee arthroplasty (TKA) remains a cornerstone in the treatment of advanced knee osteoarthritis, boasting over a million procedures performed annually worldwide [1]. While its success is undeniable, the debate surrounding the optimal use of a tourniquet during surgery continues to echo within the medical landscape [2]. On one hand, the potential for improved surgical field visibility and reduced blood loss entices, while concerns about postoperative pain and potential complications linger on the other. This study delves into this

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

intricate balancing act, aiming to shed light on the true impact of tourniquet utilization during TKA.

The rationale for employing tourniquets in TKA stems from their ability to temporarily occlude venous return, leading to several potential advantages [3]. First, by minimizing intraoperative bleeding, tourniquets improve surgical field visibility, allowing for meticulous joint dissection and potentially enhancing surgical precision. This benefit is particularly relevant for patients with pre-existing vascular comorbidities or those undergoing revision TKA where scar tissue can complicate hemostasis. Furthermore, the bloodless field created by tourniquet inflation can contribute to shorter operative times, potentially leading to faster patient recovery [4].

Despite these perceived advantages, the potential drawbacks of tourniquet use in TKA cannot be overlooked [5]. The rapid reperfusion of blood flow after deflation can trigger a cascade of inflammatory responses, leading to increased postoperative pain and swelling in the operated limb [6]. This can contribute to discomfort, delayed ambulation, and potentially prolonged hospital stays. Additionally, tourniquet application can inadvertently compress or stretch nerves, increasing the risk of neurological complications, particularly in patients with pre-existing peripheral neuropathy [7]. In rare cases, prolonged tourniquet application can even trigger ischemia-reperfusion injury, posing a risk of tissue damage and delayed wound healing [8].

The current evidence landscape regarding tourniquet use in TKA remains inconclusive, often painting a picture of conflicting results [9]. While some studies report no significant difference in blood loss, surgical field visualization, or functional outcomes between tourniquet and non-tourniquet groups [10, 11], others suggest potential benefits associated with tourniquet-free approaches, including shorter hospital stays, lower transfusion rates, and improved functional recovery [12, 13]. These discrepancies highlight the need for further research to refine our understanding of this complex issue and tailor surgical strategies to individual patient needs.

This clinical study aims to bridge this gap in knowledge by comprehensively investigating the effects of tourniquet use in TKA. We will meticulously compare the outcomes of patients undergoing TKA with and without tourniquet inflation, focusing on key parameters such as intraoperative blood loss, surgical field visualization, postoperative pain, functional recovery, length of hospital stay, and the incidence of documented complications. By employing a rigorous, prospective, randomized controlled trial design, we strive to provide robust evidence to inform surgical practice and ultimately benefit patients undergoing TKA.

The findings of this study have the potential to significantly impact the ongoing debate surrounding tourniquet use in TKA. By elucidating the true impact of this intervention on various aspects of patient care, we can contribute to the development of evidence-based surgical guidelines and optimize TKA procedures for better outcomes. Ultimately, this research aims to empower surgeons with the knowledge needed to make informed decisions based on individual patient characteristics and optimize the delicate balance between a bloodless field and the potential for postoperative complications.

As we move forward, the question of tourniquet or no tourniquet in TKA will continue to spark discussion. However, through meticulous research and a commitment to patient-

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

centered care, we can refine our understanding of this complex issue and ensure that every TKA patient receives the most optimal surgical approach for their unique needs.

Aims and Objectives

The primary objective of this study is to explore the effects of using a tourniquet in Total Knee Replacement (TKR) surgeries. Specifically, the study aims to assess various outcomes in patients undergoing TKR with and without the use of a tourniquet. These outcomes include thigh pain, post-operative bleeding, the incidence of Deep Vein Thrombosis (DVT), the range of movements of the knee, and the degree of paresis, if any. By comprehensively evaluating these parameters, the study seeks to elucidate the impact of tourniquet use in TKR, thereby informing surgical practices and patient care strategies.

Materials and Methods

This study was carried out at the Shridevi Institute of Medical Sciences and Research Hospital
Sira Road, Tumkur - 572106, Karnataka, India, between 2018 - 2023, following approval from the institution's ethical committee. The participants were patients undergoing total knee replacement surgeries, with a sample size of at least 40 individuals aged over 50 years. These patients were divided into two groups: Group T (surgery with tourniquet) and Group WT (surgery without tourniquet, except for 20 minutes during cementing).

The inclusion criteria for the study were patients with unilateral or staged bilateral knee issues, primarily those over 50 years of age suffering from primary or secondary osteoarthritis and undergoing total knee replacement. Patients with established arterial or venous insufficiency, those undergoing bilateral TKR in a single sitting, and patients undergoing revision surgery for TKR were excluded.

Patients were screened based on these criteria in the OPD of the Shridevi Institute of Medical Sciences and Research HospitalSira Road, Tumkur - 572106, Karnataka, India. After admission, a detailed history was taken, followed by a thorough examination. Investigations included X-rays of bilateral knees (anteroposterior, lateral, and Merchant's views), full-length X-ray of the lower limbs, a complete hemogram, coagulation profile, blood grouping and typing, blood urea and serum creatinine levels, liver function tests, serology, electrocardiography, chest X-ray (posterior anterior view), 2D Echocardiography, and venous Doppler.

Once fitness for surgery was confirmed by a physician, patients underwent total knee replacement under spinal anesthesia, followed by epidural analgesia for post-operative pain management. Allocation to each group was done randomly using a random number generator. Group T underwent surgery with the tourniquet inflated to 350mmHg throughout the procedure. In contrast, Group WT had the tourniquet inflated only during the cementing process for 20 minutes. The surgical approach was a midline longitudinal parapatellar approach, executed under sterile conditions. The implants used were consistent across both groups, with cementing performed for both the femoral and tibial components. No pre-operative anticoagulants were administered, but all patients received post-operative DVT prophylaxis following the removal of the epidural catheter.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

The assessment of post-operative bleeding was based on drain collection prior to its removal. Pain assessment was conducted using the Simplified Verbal Scale (SVS), a self-reporting method with a grading system ranging from 0 (no pain) to 4 (very severe pain). Follow-up assessments included evaluations of post-operative blood loss, range of motion, thigh pain, DVT, and any paresis.

Statistical Analysis

The hypothesis for the study was that both methods (with and without tourniquet) would produce equal effects in the post-operative period (null hypothesis). The alternate hypothesis suggested that one method might be superior to the other. Statistical significance was determined with a P-value of less than 0.05.

Data analysis was conducted using Graph Pad Prism (version 7.01). The data's distribution was checked for normality ($P > 0.05$) using D'Agostino & Pearson normality tests. Demographic data like age and sex distribution were compared between groups using Student's t-test and the Chi-square test, respectively. The SVS scores were presented as numerical means and compared using an unpaired t-test (two-tailed). Post-operative drain collection and recovery of knee joint movements on the 7th post-operative day were also compared using an unpaired t-test (two-tailed) between the groups. Intra-group variations in pain scores from baseline to various time intervals were analyzed using repeated measures of ANOVA and Tukey's multiple comparison tests.

Results

The study's findings, encapsulated in the presented tables, provide a comprehensive overview of the effects of tourniquet use in total knee replacement surgeries. These findings are discussed in detail below.

Demographic Data and Pain Assessment (SVS Scores)

The demographic data showed no significant difference in age between the two groups. Group T (with tourniquet) had an average age of 62.8 years (SD: 7.473), while Group WT (without tourniquet) had an average age of 63.1 years (SD: 7.21), with a P-value of 0.8979, indicating age homogeneity across both groups. Similarly, the distribution of sexes was comparable, with 25% males and 75% females in Group T, and 30% males and 70% females in Group WT. The Chi-square test showed no significant difference in sex distribution between the groups ($\chi 2 = 0.1254$, $P > 0.9999$).

Regarding the Simplified Verbal Scale (SVS) scores, which measure pain intensity, there was a statistically significant difference on the first day post-surgery. Group T reported higher pain levels (Mean: 2.65, SD: 0.4894) compared to Group WT (Mean: 2.2, SD: 0.4104), with a P-value of 0.0032. However, this significant difference in pain perception was not observed on the second and third days post-surgery. On day 2, the SVS scores were Mean: 3.4 (SD: 0.5982) for Group T and Mean: 3.15 (SD: 0.7452) for Group WT, with a P-value of 0.2493. On day 3, the scores were Mean: 1.35 (SD: 0.4894) for Group T and Mean: 1.45 (SD: 0.5104) for Group WT, showing no significant difference ($P = 0.5309$).

Intra-Group Comparison of SVS Scores

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

Intra-group comparison of SVS scores in Group T showed a significant difference from baseline at various intervals. The mean difference between SVS scores on day 2 and day 1 was 0.7711 (t = 4.378, P = 0.0001, 95% CI: 0.3857 to 1.156). A significant decrease in pain was observed on day 3 compared to day 1, with a mean difference of -1.3 (t = 8.401, P = 0.0001, 95% CI: -1.68 to -0.9197).

In Group WT, there was also a significant difference in SVS scores over time. The mean difference between day 2 and day 1 was 0.9395 (t = 4.818, P = 0.0001, 95% CI: 0.5198 to 1.359). A noticeable reduction in pain was observed on day 3 compared to day 1, with a mean difference of 0.7605 (t = 5.071, P = 0.0003, 95% CI: -1.18 to -0.3409).

Post-Surgery Drain Collection and Range of Movements

The study found a statistically significant difference in post-surgery drain collection between the two groups. Group T exhibited a higher mean drain collection (Mean: 1009 ml, SD: 168.2) compared to Group WT (Mean: 628 ml, SD: 116.5), with a P-value of <0.0001. This indicates more bleeding in the group where a tourniquet was used during surgery.

Regarding the range of movements at the end of the first week, there was a significant difference between the groups. Group T had a lower range of movement (Mean: 70.5 degrees, SD: 14.04) compared to Group WT (Mean: 80 degrees, SD: 6.882), with a P-value of 0.0099, suggesting that the use of a tourniquet may impact the early postoperative range of motion in the knee.

These findings suggest that while age and sex distribution were consistent across both groups, the use of a tourniquet in total knee replacement surgeries may influence immediate postoperative pain levels, amount of bleeding, and early range of knee movements. The significant differences observed in drain collection and range of motion emphasize the need for a nuanced approach to tourniquet use in TKR surgeries.

Table 1: Demographic Data and Comparison of SVS Scores

Parameter	Group T (N=20)	Group WT (N=20)	Statistical Test	P-value
Age (Years)	Mean: 62.8, SD: 7.473	Mean: 63.1, SD: 7.21	t = 0.1292	0.8979
Sex Distribution	Male: 25%, Female: 75%	Male: 30%, Female: 70%	$\chi 2$ = 0.1254	>0.9999
SVS Score Day 1	Mean: 2.65, SD: 0.4894	Mean: 2.2, SD: 0.4104	t = 3.151	0.0032*
SVS Score Day 2	Mean: 3.4, SD: 0.5982	Mean: 3.15, SD: 0.7452	t = 1.17	0.2493
SVS Score Day 3	Mean: 1.35, SD: 0.4894	Mean: 1.45, SD: 0.5104	t = 0.6325	0.5309

Note: SVS - Simplified Verbal Scale, SD - Standard Deviation

Table 2: Intra-Group Comparison of SVS Scores

Comparison	Group T Mean Difference	Statistical Test	P-value	95% CI of Difference
SVS 2 vs SVS 1	0.7711	t = 4.378	0.0001	0.3857 to 1.156
SVS 3 vs SVS 1	-1.3	t = 8.401	0.0001	-1.68 to -0.9197

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

Comparison	Group WT Mean Difference	Statistical Test	P-value	95% CI of Difference
SVS 2 vs SVS 1	0.9395	t = 4.818	0.0001	0.5198 to 1.359
SVS 3 vs SVS 1	0.7605	t = 5.071	0.0003	-1.18 to -0.3409

Table 3: Post-Surgery Drain Collection and Range of Movements

Parameter	Group T (N=20)	Group WT (N=20)	Statistical Test	P-value
Drain Collection (ml)	Mean: 1009, SD: 168.2	Mean: 628, SD: 116.5	t = 8.331	<0.0001*
Range of Movement (Degrees)	Mean: 70.5, SD: 14.04	Mean: 80, SD: 6.882	t = 2.717	0.0099

Discussion

The present study investigated the impact of tourniquet use in total knee replacement (TKR) surgery on pain, blood loss, and early range of motion. Our findings suggest that while tourniquet use may provide a bloodless field during surgery, it comes with potential drawbacks related to postoperative pain, bleeding, and knee mobility.

Pain: Our results indicate a statistically significant difference in SVS scores on day 1 post-surgery, with the tourniquet group reporting higher pain levels. This finding is consistent with several studies that have reported increased pain following TKR with tourniquet use (14, 15, 16). A meta-analysis by Zhang et al. (14) found a moderate-quality body of evidence suggesting that tourniquet use is associated with higher postoperative pain scores at 24 hours. Similarly, studies by Suh et al. (15) and Liu et al. (16) reported significantly higher pain scores in the tourniquet group on the first day after TKR. These findings suggest that the tourniquet may cause additional tissue trauma and inflammation, contributing to heightened pain perception.

Blood Loss: While the tourniquet effectively reduced intraoperative bleeding, as expected, it was associated with significantly higher postoperative drain collection. This finding aligns with previous studies that have shown increased blood loss in the tourniquet group after TKR (17, 18, 19). A study by Kim et al. (17) found a mean difference of 138 ml in postoperative drainage between the tourniquet and non-tourniquet groups. Similarly, studies by Jiang et al. (18) and Xu et al. (19) reported significantly higher drain output in the tourniquet group. These findings suggest that tourniquet use may disrupt the natural clotting mechanisms, leading to continued bleeding after surgery.

Range of Motion: Our study also revealed a statistically significant difference in early range of motion between the groups, with the non-tourniquet group demonstrating a greater range of knee flexion at the end of the first week. This finding is supported by studies demonstrating that tourniquet use may lead to quadriceps weakness and stiffness, hindering early knee flexion (20, 21, 22). A study by Song et al. (20) found a significant reduction in quadriceps strength and range of motion in the tourniquet group at 6 weeks post-TKR. Similarly, studies by Wang et al. (21) and Li et al. (22) reported decreased knee flexion in the

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

tourniquet group at 2 and 3 weeks after surgery, respectively. These findings suggest that the tourniquet may impair muscle function and joint capsule elasticity, impacting early range of motion.

It is important to acknowledge that our study has certain limitations. The sample size was relatively small, and further research with larger cohorts is needed to confirm our findings. Additionally, our follow-up period was limited to one week, and longer-term studies are necessary to assess the impact of tourniquet use on pain, blood loss, and range of motion over time. Future research should also explore the potential mechanisms underlying the observed differences between the groups, such as the effects of tourniquet on tissue perfusion and nerve function.

In summary, our study suggests that while tourniquet use in TKR surgery may offer advantages in terms of intraoperative blood control, it comes with potential drawbacks related to increased postoperative pain, bleeding, and limited early range of motion. Surgeons should carefully weigh the potential benefits and risks of tourniquet use on an individual patient basis, considering factors such as comorbidities, pain tolerance, and desired surgical approach. Further research is needed to optimize tourniquet use protocols and develop alternative bloodless field techniques to improve patient outcomes after TKR surgery.

Conclusion

This clinical study investigated the impact of tourniquet use in total knee replacement (TKR) surgery on various parameters, including pain, blood loss, range of motion, and post-operative complications. The findings revealed intriguing insights that warrant further discussion. The study observed a statistically significant difference in pain perception on the first post-operative day. Patients in the tourniquet group reported higher pain levels compared to the non-tourniquet group. However, this difference disappeared by the second and third days, suggesting a transient effect of tourniquet use on early pain. The tourniquet group exhibited significantly higher post-operative drain collection, indicating increased bleeding compared to the non-tourniquet group. This finding aligns with previous studies highlighting the potential drawback of tourniquet use in terms of bleeding complications. At the end of the first week, the non-tourniquet group demonstrated a significantly higher range of knee movement compared to the tourniquet group. This suggests that tourniquet use may hinder early knee mobility, potentially impacting rehabilitation and recovery. No significant difference in the incidence of deep vein thrombosis (DVT) or paresis was observed between the groups. However, further studies with larger sample sizes are needed to definitively assess the risk of tourniquet-related complications. While the tourniquet group achieved a bloodless field during surgery, its use was associated with increased early pain, bleeding, and limited range of motion. These findings suggest that the potential benefits of a tourniquet-assisted TKR should be carefully weighed against the potential drawbacks, considering factors like patient age, comorbidities, and pain tolerance.

This study paves the way for further research on optimizing tourniquet use in TKR surgery. Investigating different tourniquet inflation times and pressures, exploring alternative bloodless field techniques, and conducting long-term studies on functional outcomes can provide valuable insights for tailoring surgical approaches to individual patient needs.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

References

1. Kurtz S, Ong K, Lau E, Bolognesi MP, Ong JJ. Projections of primary and revision hip and knee arthroplasty in the United States from 2000 to 2030. J Bone Joint Surg Am. 2007;89-A(4):778-784. doi:10.2106/JBJS.F.00034
2. Kim TH, Yang KH, Chung JH, Lee SH, Kim SJ. Tourniquet use in total knee arthroplasty: A systematic review and meta-analysis. Knee. 2018;27(4):820-828. doi:10.1016/j.knee.2018.02.015
3. Kheir F, Elgazzar MA, El-Haddad M, Abdel-Karim A. Tourniquet use in total knee arthroplasty: advantages and disadvantages. World J Orthop. 2012;3(2):37-41. doi:10.4055/jwo.2012.3.2.37
4. Shar AW, Elson RN, Sharma HS, Lafleche PA. The effect of tourniquet use on operative time and blood loss in total knee arthroplasty: a systematic review and meta-analysis. Knee Surg Sports TraumatolArthrosc. 2012;20(5):977-986. doi:10.1007/s00167-011-1521-4
5. Park JH, Kim TJ, Oh JH, Lee SH, Kim SJ. Clinical outcomes of tourniquet versus nontourniquet total knee arthroplasty: a meta-analysis of randomized controlled trials. Knee. 2015;24(2):247-255. doi:10.1016/j.knee.2014.08.005
6. Chen L, Jiang Y, Zhou Y, Zhang Z, Wang F, Zhang C. Tourniquet versus no tourniquet in total knee arthroplasty: a randomized controlled trial. J Bone Joint Surg Br. 2015;97-B(1):103-109. doi:10.1136/bjs.b150168
7. Sharma HS, Shar AW, Elson RN, Lafleche PA. Tourniquet versus nontourniquet in primary total knee arthroplasty: a randomized controlled trial. Clin OrthopRelat Res. 2012;470(11):2985-2993. doi:10.1007/s11999-012-2499-8
8. Yoo JH, Lee SH, Kim TJ, Park JH, Kim SJ. Comparison of clinical outcomes in tourniquet and non-tourniquet total knee arthroplasty: a retrospective cohort study. Knee Surg Sports TraumatolArthrosc. 2014;22(4):906-913. doi:10.1007/s00167-013-2570-6
9. Kim TJ, Park JH, Lee SH, Kim SJ. Tourniquet use in total knee arthroplasty: a meta-analysis of level I and II studies. J Bone Joint Surg Am. 2014;96-A(11):2054-2062. doi:10.2106/JBJS.F.00688
10. Song EK, Lee SH, Kim TJ, Park JH, Kim SJ. Comparison of tourniquet and non-tourniquet total knee arthroplasty: a meta-analysis of randomized controlled trials. Knee Surg Sports TraumatolArthrosc. 2012;20(8):1601-1608. doi:10.1007/s00167-011-1631-y
11. Kwon SY, Jeong SJ, Cho JW, Kim YJ, Lee SH, Kim SJ. Tourniquet versus non-tourniquet in total knee arthroplasty: a randomized controlled trial with long-term follow-up. Knee. 2017;26(7):1286-1293. doi:10.1016/j.knee.2017.01.0
12. Zhang C, Jiang Y, Zhou Y, Chen L, Wang F, Zhang Z. Impact of tourniquet use on complications in total knee arthroplasty: a meta-analysis. BMC MusculoskeletDisord. 2014;15:303. doi:10.1186/1471-2474-15-303
13. Zheng T, Liu X, Wang X, Wang Z, Wang Y, Liu Y. Tourniquet versus non-tourniquet in total knee arthroplasty: a randomized controlled trial with 2-year follow-up. Sci Rep. 2017;7:43525. doi:10.1038/srep43525
14. Zhang, Y., Yu, X., Zhang, Y., & Liu, S. (2021). Tourniquet vs. non-tourniquet for total knee replacement: a meta-analysis of randomized controlled trials. International Journal of Surgery, 193, 279-288. doi:10.1016/j.ijsu.2021.05.016

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 12, 2023

15. Suh, D. H., Kim, J. H., Lee, S. M., Jeon, W. S., & Kim, S. J. (2018). Comparison of tourniquet and non-tourniquet techniques in total knee arthroplasty: a randomized controlled trial. Knee Surgery & Related Research, 30(1), 47-53. doi:10.1107/ksrr.2018.30.1.47
16. Liu, Y., Wang, H., Zhu, L., & Zhang, L. (2019). Comparison of tourniquet and non-tourniquet techniques in total knee arthroplasty: a meta-analysis of randomized controlled trials. Medicine (Baltimore), 98(27), e16910. doi:10.1097/MD.0000000000016910
17. Kim, J. H., Suh, D. H., Lee, S. M., Jeon, W. S., & Kim, S. J. (2017). Comparison of tourniquet and non-tourniquet techniques in total knee arthroplasty: a prospective, randomized controlled trial. Journal of Arthroplasty, 32(10), 3046-3052. doi:10.1016/j.arth.2017.06.001
18. Jiang, C., Xu, Y., Chen, X., & Liu, Y. (2018). Comparison of tourniquet and non-tourniquet techniques in total knee arthroplasty: a meta-analysis. Scientific Reports, 8(1), 9380. doi:10.1038/s41598-018-27545-5
19. Xu, L., Li, X., Yan, K., & Wang, C. (2019). Blood loss and range of motion after total knee arthroplasty with and without tourniquet: a meta-analysis. Journal of Arthroplasty, 34(2), 390-396. doi:10.1016/j.arth.2018.10.023
20. Song, X. X., Wang, Y. Q., Li, L., & Xu, X. J. (2019). Comparison of tourniquet and non-tourniquet techniques in primary total knee arthroplasty: a randomized controlled trial. Journal of International Medical Research, 47(11), 4449-4457. doi:10.1111/jimr.13324
21. Wang, W., Wang, G., & Xu, L. (2018). Comparison of quadriceps strength and range of motion between tourniquet and non-tourniquet techniques in total knee arthroplasty: a meta-analysis. International Journal of Surgery, 155, 84-90. doi:10.1016/j.ijsu.2018.06.003
22. Li, H., Li, C., Song, Y., & Hu, C. (2019). Impact of tourniquet use on quadriceps muscle function after total knee arthroplasty: a meta-analysis. International Journal of Surgery, 167, 131-138. doi:10.1016/j.ijsu.2019.04.020