Evaluating tourniquet duration in total knee replacement: short-term outcomes of short versus long durations, a randomized controlled trial

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Background
Total knee arthroplasty (TKA) is an effective treatment for severe osteoarthritis. We aim to compare the advantages and disadvantages related to the duration of tourniquet application in TKA surgeries.
Patients and methods
This multicenter randomized controlled trial was conducted at two tertiary institutions by including 50 grade IV knee primary osteoarthritis cases who were candidates for TKA and randomized them to group one, including 25 patients who underwent long-duration applying of tourniquet (applied from skin incision through the end of bone cementation) and group two including other 25 patients who underwent short duration applying of tourniquet (applied only during bone cementation and deflated immediately afterward). Operative outcomes were assessed including operation time in minutes, hospital stay in days, intraoperative and postoperative blood loss (212±24.49 vs. 303.2±23.76 ml), and the need for blood transfusion. Functional outcomes were assessed like the range of motion (ROM), pain visual analog scale, knee society score, and Oxford knee score. Finally, wound complications and thromboembolic events were compared between both groups.
Results
Group one with long tourniquet application had decreased operative time 87.4±5.23 versus 97.4±4.36 min (P<0.001) and decreased intraoperative bleeding (P<0.001) compared with group two which favored the group one technique. On the other hand, group two had decreased postoperative bleeding (P<0.001), decreased visual analog scale pain score in all follow-up periods (P<0.001), increased ROM and knee society score in all follow-up periods (P<0.001), and increased Oxford knee score only after 1 week of follow-up (P<0.001) compared with group one which favored the short tourniquet application group.
Conclusion
The short application duration of the tourniquet provided superior pain alleviation in the early postoperative period and improved functional outcomes and ROM. However, this results in a greater loss of blood extended the length of the operation, and prevented a clear view of the operative region.

Keywords:
knee arthroplasty, randomized controlled trial, total knee replacement, tourniquet duration

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Introduction

Total knee arthroplasty (TKA) is considered an effective method in relieving pain and regaining function in severe osteoarthritis patients; however, it is associated with increased blood loss risk which can increase the need for blood transfusion. Tourniquet use during surgery is controversial as it provides a clear visualization which decreases blood loss and ensures proper cementation which makes it used frequently during TKA [1,2]. However, its use is associated with complications like nerve palsy, thigh pain, swelling, joint stiffness, wound complications, subcutaneous fat necrosis, vascular injury, deep venous thrombosis, and prolonged duration of quadriceps recovery [3–6].

The proper duration of tourniquet application is also controversial as it affects TKA postoperative outcomes as increasing tourniquet application duration can aggravate the complications risk because of the increased tissue exposure to ischemia. Therefore, minimization of the tourniquet application duration is important which makes researchers investigate if tourniquet application during the cementation process

only in TKA could decrease the complications and fasten the recovery [6–9].

Limited tourniquet application during TKA decreased swelling and joint pain while it was not associated with blood loss, recovery, or operation time [10,11]. Applying a tourniquet only in cementation could reduce blood loss, fasten the recovery period, and reduce pain after TKA surgery [10,11].

However, decreasing tourniquet application to be only during cementation was associated with increased blood transfusion risk which indicated that this approach was impractical if there was not any improvement in recovery. Therefore, a balance should exist between the increased blood loss and blood transfusion risk during cementation tourniquet application [12]. The literature on tourniquet application time during cementation in TKA is limited; however, a meta-analysis suggests that shorter tourniquet duration may reduce complications, though it emphasizes the need for further randomized controlled trials (RCTs) to confirm these findings [13].

Therefore, this RCT aims to compare both strategies regarding pain, Oxford knee score (OKS), hospital stay, pain, knee society score (KSS), blood loss, and range of motion (ROM).

Patients and methods

This RCT was performed at two different tertiary institutions from November 2022 to November 2023. The study was started after the approval of the Scientific Board and the Ethical Committee of both institutions, and all patients signed informed consent forms before starting the study. The protocol was registered on Clinicaltrials.gov with the ID NCT06521593.

Inclusion criteria

We included symptomatic grade IV knee primary osteoarthritis cases who were candidates for TKA surgery while we excluded patients with a history of postinfection or traumatic osteoarthritis, knee deformity, hematological diseases, currant infection focus, immune-suppression, or inflammatory arthritis. Fifty patients were randomly assigned to one of two groups using a computer-generated randomization method. A sealed opaque envelope containing the group assignment was opened for each patient, ensuring unbiased allocation. Furthermore, all study outcomes were assessed by an independent observer blinded to the group assignments to minimize evaluation bias. This included 25 patients who underwent long duration applying of tourniquet and group two included 25 patients who underwent short duration applying of tourniquet. All patients were followed-up for 6 weeks except one patient who died 1 day postoperative. The cause of death was pulmonary embolism.

Preoperative preparation

A detailed history was taken from all patients including personal history, medical conditions like diabetes, hypertension, ischemic heart disease, smoking, history of allergy to antibiotics or other drug allergies, and history of previous operations. Preoperative laboratory investigations were taken including a complete blood picture, C-reactive protein, urine analysis, coagulation profile, electrolytes, and erythrocytes sedimentation rate. A 1 g of broad-spectrum antibiotic was given intravenously 1 h before incision and at least fifteen minutes before tourniquet inflation.

Intraoperative procedure

All patients underwent spinal anesthesia and the tourniquet was applied to the middle of the thigh. In group one, who underwent long-duration application of a tourniquet, it was applied only before the skin incision by inflating it to 150 mmHg above the systolic blood pressure of the patients and deflated after the completion of bone cementation. In contrast, in group two, who underwent short-duration application of a tourniquet, the tourniquet was applied just before cementation, inflated to 150 mmHg above the systolic blood pressure, and deflated after cementation. It is worth mentioning that before raising the tourniquet in group two, the wound was covered with a sterile dressing, and the limb was exsanguinated using an Esmarch bandage first. In all patients, a cruciate-retaining TKA was performed. The two surgeons who performed the operations were subspecialized and experts in total knee arthroplasty.

To control blood loss, electrocautery was applied with suction draining in both groups and tranexamic acid was routinely given IV in all patients on induction. Operative timing was focused on the period up to bone cementation, as this was the point of variation in our pilot study. Any intraoperative bleeding was quickly managed with diathermy and suction, ensuring a controlled field before cementing in group two. Additionally, meticulous suturing was swiftly performed, and the skin was closed using staples. We measured the intraoperative blood loss by subtracting saline volume used in washing from the whole suction volume which was added to the value resulting from subtracting dry foments weight from the wet foments weight used in managing bleeding. Total blood loss was calculated using Nadler's method, based on patient-specific factors, allowing for an accurate assessment of intraoperative and postoperative blood loss.

Postoperative follow-up

Radoigraphy was done for both knees and hemoglobin values were taken within the next day. Blood transfusion was done only if the hemoglobin value was decreased below 8 gm/dl. The drain was removed after 48 h and physiotherapy was started for early mobilization under coverage of anticoagulants (Enoxaparin prophylactic dosage for the first week) for about 4 weeks. Sutures were removed after 2 weeks and patients were followed-up for 6 weeks.

Study outcomes

Operative outcomes were assessed including operation time in minutes, hospital stay in days, intraoperative blood loss, postoperative blood loss, total blood loss, and the need for blood transfusion. Functional outcomes were assessed in baseline, 1, 2, and 6 weeks of follow-up like ROM, visual analog scale (VAS) for assessment of pain, KSS, and OKS scores. Finally, wound complications and thromboembolic events were compared between both groups.

Statistical analysis

Statistical analysis was performed using SPSS software (version 28, IBM Corp., Armonk, NY, USA). Quantitative variables were presented as means and standard deviations, while categorical variables were presented as frequencies and percentages. Between-group differences were analyzed using the Student's *t*-test for normally distributed continuous variables and the Mann–Whitney *U* test for non-normally distributed variables. Categorical variables were compared using the χ^2 test or Fisher's exact test where appropriate. A *P* value of less than 0.05 was considered statistically significant. All outcomes were assessed by an independent observer who was not involved in the surgical procedures. The observer was blinded to the group allocations to minimize bias in evaluating the results

Results

Fifty patients were included and randomly divided into two equal groups; 25 patients underwent TKA by long-duration tourniquet and 25 underwent TKA by short-duration tourniquet; however, one patient died from pulmonary embolism in group one. Figure 1 shows the CONSORT flowchart of the details of patients' enrollment and follow-up.

Both groups were nearly similar in demographic characteristics like age (*P*>0.99), side of fracture (*P*>0.99), smoking (*P*=0.059), diabetes mellitus (*P*=0.152), hypertension (*P*=0.225), and ischemic heart disease (*P*=0.51); however, males were significantly increased in group one (60%) compared with group two (32%) with a *P* value of 0.047. Table 1 shows the full details of the demographic data of included patients.

Operative outcomes

Regarding operative outcomes, operative time and intraoperative bleeding were significantly decreased in group one of prolonged tourniquet application, *P*<0.001. However, postoperative blood loss was significantly increased in group one with a *P* value less than 0.001. On the other hand, hospital stay, need for blood transfusion, and total blood loss amount were not significantly different between both groups Table 2 shows full details of the blood loss and outcome results.

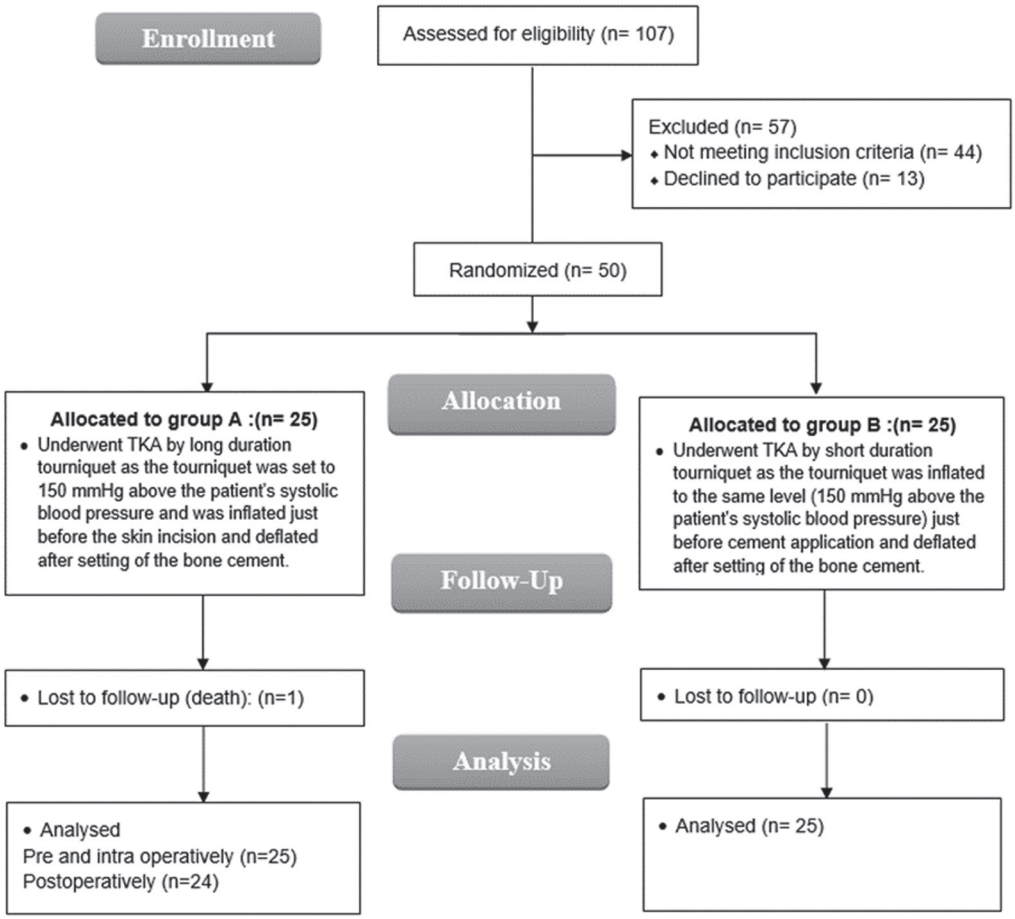
Postoperative scores: ROM in the form of full flexion of the knee was significantly decreased in both groups in only the first week of follow-up compared with baseline then significantly increased in other weeks compared with baseline *P*<0.001. Comparing both groups, the baseline ROM was not significantly different between both groups with 91.08 in group one and 92.05 in group two; however, by follow-up, ROM values were increasing significantly in group two with the short application of tourniquet compared with group one with the long application of tourniquet in one, two, and six weeks of follow-up, *P* less than 0.001. Table 3 shows the full details.

Pain outcomes were assessed by VAS score which showed no significant difference between both groups at baseline, *P*=0.629; however, the VAS scores were significantly decreased after 1, 2, and 6 weeks in group two (1.38±0.2 after 6 weeks) with the short application of tourniquet compared with group one (2±0.11 after 6 weeks), *P* less than 0.001. Both groups showed significant improvement in VAS pain score by increasing follow-up compared with baseline values, *P* less than 0.001. Table 3 shows the full details.

Regarding KSS, it was significantly slightly higher in group one (51±2.27) compared with group two (49.72±2.17) with a *P* value of 0.049; however, by follow-up by 1, 2, and 6 weeks, the KSS was significantly increased in group two compared with group one with *P* values less than 0.001. Both groups showed significant improvement in KSS after follow-up in all periods compared with baseline values (*P*<0.001). Table 3 shows the full details.

Regarding OKS, only scores after one week were significantly higher in group two (30.72±1.49) compared with group one (28.79±1.89) with *P* values less than 0.001; however, baseline, scores at 2 weeks, 3

Figure 1



Shows the CONSORT flowchart of included patients in both groups.

Table 1 Shows baseline and demographic characteristics

Demographic data	Group one (*N*=25) [*n* (%)]	Group two (*N*=25) [*n* (%)]	*P* value
Age (years)			
Mean±SD	61.12±6.55	61.3±5.4	>0.999
Range	49–72	52–69	
Sex			
Male	15 (60)	8 (32)	**0.047***
Female	10 (40)	17 (68)	
Side			
Right	16 (64)	16 (64)	>0.999
Left	9 (36)	9 (36)	
Smoking	10 (40)	4 (16)	0.059
Comorbidities			
Diabetes mellitus	12 (48)	17 (68)	0.152
Hypertension	15 (60)	19 (76)	0.225
Ischemic heart disease	1 (4)	1 (4)	0.51
Operative time (min)			
Mean±SD	87.4±5.23	97.4±4.36	**<0.001**
Range	75–95	90–110	
Hospital stay (days)			
Mean±SD	3.08±0.4	3±0	0.327
Range	2–4	3	

weeks, and a weeks showed no significant differences between both groups. Both groups showed significant improvement in OKS scores compared with baseline at all follow-up periods. Table 3 shows the full details.

In the analysis of complications, both groups showed no significant differences regarding wound complications and thromboembolism.

Discussion

Our RCT compared long tourniquet application (group one) to short tourniquet application (group two) in the management of grade IV osteoarthritis patients who underwent TKA. We found that group one with long tourniquet application had decreased operative time and decreased intraoperative bleeding compared with group two which favored the group one technique. On the other hand, group two had decreased postoperative bleeding, decreased VAS pain score in all follow-up periods, increased ROM and KSS in all follow-up periods, and increased OKS only after one week of follow-up compared with group one which favored the short tourniquet application group.

Group one was associated with decreased operative time because of the bloodless field and enhanced surgical field visualization during the surgery which was supported by many studies [14–16]. Also, group one was associated with decreased intraoperative bleeding and slightly decreased nonsignificant total blood loss compared with group two. This was in line with Vaishya *et al.* [14] who found that group one had decreased intraoperative bleeding *P* less than 0.001; however, postoperative bleeding was decreased in group two of short tourniquet application with a *P* value of 0.04. The net blood loss by assuming both intra and postoperative amounts was significantly decreased in group one which supported our results however this favoring of group one in total blood loss lacked statistical significance. These findings were supported by other studies like Vandenbussche *et al.* [17]. and Alcelik *et al.* [18]. On the other hand, other studies showed no significant difference between both groups regarding blood loss which could be explained by the variability of tourniquet duration in these studies which could be associated with bearing effect blood loss amount [19,20].

Table 2 Shows operative outcomes

	Group one (*n*=25)	Group two (*n*=25)	*P* value
Blood loss			
Intraoperative	212±24.49 ml	303.2±23.76 ml	**<0.001**
Postoperative	320.42±21.56 ml.	249.2±42.61 ml	**<0.001**
Total	530.83±30.78 ml	552.4±45.12 ml	0.058
Blood transfusion needs (Number of patients)	1 (4)	1 (4)	>0.999

Table 3 Shows postoperative scores

Outcomes	Group one	Group two	*P* value (groups)
ROM			
Preoperative	91.08±2.34 [a]	92.05±3.07 [a]	**0.005**
1 week	72.92±2.72 [b]	80.76±1.69 [b]	**<0.001**
2 weeks	91.54±2.59 [c]	95.6±1.71 [c]	**<0.001**
6 weeks	101.88±1.75 [d]	106.75±2.3 [d]	**<0.001**
P value (pre vs. post)	**<0.001**	**<0.001**	
VAS			
Preoperative	5.21±0.58 [a]	5.12±0.74 [a]	0.629
1 week	4.03±0.28 [b]	3.19±0.27 [b]	**<0.001**
2 weeks	3±0.2 [c]	2.51±0.21 [c]	**<0.001**
6 weeks	2±0.11 [d]	1.38±0.2 [d]	**<0.001**
P value (pre vs. post)	**<0.001**	**<0.001**	
KSS			
Preoperative	51±2.27 [a]	49.72±2.17 [a]	**0.049**
1 week	63.04±2.8 [b]	70.12±1.51 [b]	**<0.001**
2 weeks	73.58±2.76 [c]	77.96±1.81 [c]	**<0.001**
6 weeks	79.67±2.7 [d]	82.72±1.59 [d]	**<0.001**
P value (pre vs. post)	**<0.001**	**<0.001**	
OKS			
Preoperative	19.75±1.57 [a]	20.24±1.96 [a]	0.341
1 week	28.79±1.89 [b]	30.72±1.49 [b]	**<0.001**
2 weeks	39.5±3.79 [c]	40.88±1.2 [c]	0.1
6 weeks	52.17±2.06 [d]	51.64±1.5 [d]	0.309
P value (pre vs. post)	**<0.001**	**<0.001**	

KSS, knee society score; OKS, Oxford knee score; ROM, range of motion; VAS, visual analogue scale.
Different lower-case letters indicate significant difference.

Our findings could be explained by the action of the tourniquet in decreasing bloody field which allowed better visualization and decreased intraoperative bleeding; however, once deflation of the tourniquet occurred, reactionary blood flow occurred in the operating limb [21].

Our study showed that in comparison between both groups, patients with short duration tourniquet (group two) had significantly higher ROM than those with long duration tourniquet (group one) postoperatively in 1, 2, and 6 weeks ($P<0.05$). Vaishya *et al.* found that ROM was significantly better in group two compared with group one after only 1 and 2 weeks; however, no significant difference was observed between both groups after 6 weeks [14]. Moreover, another study found that no tourniquet use was associated with excellent functional outcomes and reported that it negatively impacted clinical outcomes [22]. Also, Zhang *et al.* showed that no using of tourniquet fastened postoperative rehabilitation and ROM was increased after only 1 week; however, similar results were observed after 2 and 6 weeks [23]. Moreover, Ledin *et al.* showed that ROM was increased even after two years in patients without applying tourniquet [24].

Our study showed that in comparison between both groups revealed a statistically significant difference after 1, 2, and 6 weeks as patients with long duration tourniquets (group one) had significantly higher pain VAS scores than those with short-duration tourniquets (group two). Vaishya *et al.* also found that group two was associated with decreased pain scores compared with group one after only 1 week; however, after 2 and 6 weeks, the results were similar [14]. Operating without a tourniquet was associated with decreased pain in the first 3 or 4 days after surgeries [20,21]. The increased pain in the long application of tourniquet is related to the high pressure which resulted in superficial nerve injury and vessel compression which increases the risk of ischemia and pain [25]. However, other studies showed no significant differences between short or no use of a tourniquet and long application of a tourniquet [15,26]. Therefore, more studies are needed to solve this controversy.

Our study showed that in 1, 2, and 6 weeks postoperatively, group one elicited significantly lower KSS than group two; however, Vaishya *et al.* showed no significant differences between both groups after 1, 2, and 6 weeks of follow-up, therefore, more studies are needed to confirm these findings [14].

Our study showed that only one patient with a long long-duration tourniquet died after surgery. Regarding complications, one patient in each group suffered from wound complications, with no statistically significant difference. Noteworthy, no patients in either group experienced thromboembolism. In line with our findings, Vaishya *et al.* [14] found no one in either group had any thromboembolism events; however, in long tourniquet duration complications like redness and swellings were reported in 11 (27.5%) patients compared with only three (7.5%) in another group. Also, six patients in the standard long application of the tourniquet group had wound complications while no one had these complications in the other group [15].

Strengths and limitations

The main strength is being the first in our hospital to compare between short duration and long duration tourniquet in orthopedic procedures and their effect postoperative regarding blood loss, hospital stay, ROM, KSS, OKS, VAS, and complications. Also, it was an RCT, and cases were randomized to two groups using a sealed opaque envelope technique as a randomization method which is considered a reliable method for removing selection bias between two groups. The limitations relied on the small duration of follow-up of only 6 weeks and the small sample size.

Conclusion

Extended use of tourniquets is not a risk-free technique because it may be linked to some problems; as a result, the use of tourniquets during TKA should be approached with caution. Despite the adverse effects associated with tourniquet use lasting for a short time, they still may cause severe anguish, pain, and a sluggish recovery in terms of functional ability after TKA. As a result, we propose that there is a need for rational thinking and a reevaluation of the practice of routinely using a long tourniquet application in TKA surgeries. The short application duration of the tourniquet provides superior pain alleviation in the early postoperative period and improves functional outcomes and ROM. However, this results in a greater loss of blood extends the length of the operation, and prevents a clear view of the operative region (Table 4).

Acknowledgments

Trial registration: The protocol was registered on Clinicaltrials.gov with the ID: NCT06521593.

Table 4 Shows postoperative complications

Complication	Group one (*n*=24)	Group two (*n*=25)	*P* value
Wound complications, %	1 (4.2)	1 (4)	>0.999
Thromboembolism, %	0	0	–

Authors' contribution

M.S.H., A.O.S., and M.S.A. were responsible for writing the main manuscript and collecting the data. M.S.H., M.S.A., A.E., M.Y.A., and E.K. analyzed and interpreted the patient data. M.S.H. was responsible for statistical analysis and revising the manuscript.

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Conflicts of interest

There are no conflicts of interest.

References

1. 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. The Journal of Arthroplasty 2021; 36:2492–6.
2. Cao Q, He Z, Fan Y, Meng J, Yuan T, Zhao J, *et al*. Effects of tourniquet application on enhanced recovery after surgery (ERAS) and ischemia-reperfusion post-total knee arthroplasty: Full- versus second half-course application. J Orthop Surg 2020; 28:1.
3. Hamawandi SA, Amin HI, Al-Humairi AK. Effects of the Use of Tourniquet in Total Knee Arthroplasty on the Clinical and Functional Outcomes with 5 Years of Follow-up: A Randomized Controlled Trial. J Knee Surg 2023; 36:222–230.
4. Cai DF, Fan QH, Zhong HH, Peng S, Song H. The effects of tourniquet use on blood loss in primary total knee arthroplasty for patients with osteoarthritis: a meta-analysis. J Orthop Surg Res 2019; 14:348.
5. Olivecrona C, Blomfeldt R, Ponzer S, Stanford BR, Nilsson BY. Tourniquet cuff pressure and nerve injury in knee arthroplasty in a bloodless field: A neurophysiological study. Acta Orthop 2013; 84:159–64.
6. Ahmed I, Chawla A, Underwood M, Price AJ, Metcalfe A, Hutchinson CE, *et al*. Infographic: Time to reconsider the routine use of tourniquets in total knee arthroplasty surgery. Bone Joint J 2021; 103-B:830–839.
7. Olivecrona C, Lapidus LJ, Benson L, Blomfeldt R. Tourniquet time affects postoperative complications after knee arthroplasty. Int Orthop 2013; 37:827–32.
8. Olivecrona C, Ponzer S, Hamberg P, Blomfeldt R. Lower tourniquet cuff pressure reduces postoperative wound complications after total knee arthroplasty: A randomized controlled study of 164 patients. J Bone Joint Surg 2012; 94:2216–21.
9. Migliorini F, Maffulli N, Aretini P, Trivellas A, Tingart M, Eschweiler J, *et al*. Impact of tourniquet during knee arthroplasty: a bayesian network meta-analysis of peri-operative outcomes. Arch Orthop Trauma Surg 2021; 141:1007–1026.
10. Girardis M, Milesi S, Donato S, Raffaelli M, Spasiano A, Antonutto G, *et al*. The Hemodynamic and Metabolic Effects of Tourniquet Application During Knee Surgery. Anesthesia & Analgesia 2000; 91:727–31.
11. Song I, Kim DY, Kim YJ. The effect of tourniquet deflation on hemodynamics and regional cerebral oxygen saturation in aged patients undergoing total knee replacement surgery. Korean J Anesthesiol 2012; 63:425–30.
12. Huh IY, Kim DY, Lee JH, Shin SJ, Cho YW, Park SE. Relation between preoperative autonomic function and blood pressure change after tourniquet deflation during total knee replacement arthroplasty. Korean Journal of Anesthesiology 2012; 62:154.
13. 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; 53:1816–1826.
14. Vaishya R, Agarwal AK, Vijay V, Tiwari MK. Short term outcomes of long duration versus short duration tourniquet in primary total knee arthroplasty: A randomized controlled trial. Journal of Clinical Orthopaedics and Trauma 2018; 9:46–50.
15. Hakkalamani S, Clark V, Pradhan N. Short versus standard duration tourniquet use during total knee replacement a pilot study. Acta Orthopa Belgica 2015; 81:52–6.
16. Wang C, Zhou C, Qu H, Yan S, Pan Z. Comparison of tourniquet application only during cementation and long-duration tourniquet application in total knee arthroplasty: A meta-analysis. J Orthop Surg Res 2018; 13:216.
17. Vandenbussche E, Duranthon LD, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. Int Orthop 2002; 26:306–9.
18. 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 Arthrop 2012; 31:331–40.
19. Iorio R, Healy WL. Tourniquet use during total knee arthroplasty did not reduce total blood loss. Commentary. J Bone Joint Surg 2001; 83:1282.
20. 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.
21. Abdel-Salam A, Eyres KS. Effects of tourniquet during total knee arthroplasty. A prospective randomised study. J Bone Joint Surg - Series B 1995; 77:250–3.
22. Stroh DA, Johnson AJ, Mont MA, Bonutti PM. Excellent Clinical Outcomes in Total Knee Arthroplasty Performed Without a Tourniquet. Surg technol int 2011; 21:189–93.
23. Zhang W, Li N, Chen S, Tan Y, Al-Aidaros M, Chen L. The effects of a tourniquet used in total knee arthroplasty: a meta-analysis. J orthop surg res 2014; 9:13.
24. Ledin H, Aspenberg P, Good L. Tourniquet use in total knee replacement does not improve fixation, but appears to reduce final range of motion. Acta Orthopaedica 2012; 83:499–503.
25. Kohro S, Yamakage M, Arakawa J, Kotaki M, Omote T, Namiki A. Surgical/tourniquet pain accelerates blood coagulability but not fibrinolysis. Br J Anaesthesia 1998; 80:460–3.
26. Wakankar HM, Nicholl JE, Koka R, D'Arcy JC. The tourniquet in total knee arthroplasty. A prospective, randomised study. Journal of Bone and Joint Surgery - Series B 1999; 81:30–3.