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KNEE ARTHROPLASTY

Impact of tourniquet use in total knee arthroplasty on functional recovery and postoperative pain: a prospective study

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Abstract

Background Tourniquet use during total knee arthroplasty (TKA) remains controversial. The purpose of this study is to determine the impact of tourniquet use only during cementation compared with its use throughout the entire surgery concerning early outcomes in functional recovery, pain, quadriceps function, and rehabilitation.

Methods Between November 2019 and March 2020, 118 patients were enrolled in this study, with 59 patients undergoing TKA with a tourniquet during the entire surgery (group 1) and 59 patients with a tourniquet only during cementation (group 2). Twenty-eight patients were unable to complete follow-up leaving fifty in group 1 and forty in group 2. Primary endpoints were surgical time, postoperative knee and thigh pain, and functional recovery. Secondary endpoints were 6-month clinical scores and blood loss.

Results Patients in group 1 had statistically significantly increased knee pain on postoperative day 3 ($p=0.004$), and thigh pain on postoperative day 1 ($p<0.001$), 2 ($p<0.001$), and 3 ($p=0.027$), and longer time intervals to achieve straight leg raise maneuver ($p=0.006$) compared to group 2.

However, it did not affect overall narcotic consumption, knee pain (day 1–2), functional recovery, ROM, ability to do the first walk, Oxford knee score, length of stay, and complication rate.

There was no statistically significant difference in terms of 6-month postoperative knee score, surgical time, and blood loss between the two groups.

Conclusion Tourniquet use diminishes quadriceps function and increases postoperative thigh pain and, to a lesser extent, knee pain. We, therefore, recommend the use of a tourniquet only during cementing.

Level of evidence 1; prospective randomized study.

Keywords Functional recovery · Postoperative pain · Rehabilitation · Total knee arthroplasty · Tourniquet

Introduction

Total knee arthroplasty (TKA) is an effective treatment for end-stage knee osteoarthritis. In the United States, a vast majority of TKA are performed with a tourniquet but their use remains controversial [1]. Studies show that tourniquet use improves cement penetration depth, intraoperative visibility, may improve mid-term implant stability, decreases intraoperative blood loss, and surgical time [2–11]. However, some studies show that their eviction is associated with improved postoperative functional recovery, lower risks of thromboembolic complications, and less narcotic consumption [6, 8, 9, 12–14].

The literature is divisive on how tourniquet use during TKA can affect all of the abovementioned endpoints which motivated the current randomized control study.

The purpose of the study is to determine the impact in the early postoperative period of tourniquet just during cementation (8–12 min) compared with a tourniquet use during the entire surgery. Primary outcomes were surgical time, postoperative range of motion (ROM), pain, quadriceps function and functional recovery.

Our primary hypothesis was that the use of tourniquet during the entire surgery would increase postoperative pain and delay postoperative functional recovery as compared to tourniquet used only during cementation.

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Material and methods

Patients

This prospective, randomized study was conducted at an academic hospital and was approved by the institution's ethic committee.

Between November 2019 and March 2020, patient aged between 45 and 90 years with end-stage knee osteoarthritis of grade four according to Kellgren–Lawrence classification requiring unilateral TKA were considered eligible for this prospective study.

Exclusion criteria were patients (1) not willing and able to comply with follow-up requirements, (2) with chronic pain management issues, (3) neuromotor conditions, (4) loss to follow-up, (5) antecedent of knee arthrotomy and/or hardware implantation around the knee joint.

One hundred eighteen patients meeting study criteria were enrolled. Before the surgery, patients were randomized into two groups through a computer-randomization system.

Fifty-nine patients were included in group 1 (tourniquet during the entire surgery) and fifty-nine in group 2 (tourniquet only during component cementation).

Twenty-eight patients were lost to follow-up. These patients were consequently excluded. Finally, 50 patients in group 1 and 40 patients in group 2 were eligible for the study (Fig. 1, flowchart). The high rate of loss to follow-up is explained by the COVID-19 pandemic. Following governments' recommendations, many patients canceled their 6-month follow-up visit because of the virus outbreak.

Patients' baseline characteristics were compared between the two groups.

Demographics included age and gender. Comorbidities comprised body mass index (BMI), diabetes, hypertension, and rheumatoid arthritis. Laboratory values included preoperative and postoperative hemoglobin (Hb) and hematocrit (Hc). Preoperative blood tests were done in the month preceding the surgery. Operative variables included tourniquet time, laterality, and type of anesthesia.

Primary endpoints were surgical time, postoperative knee and thigh pain, and functional recovery. Secondary endpoints were 6-month Oxford knee score (OKS) and blood loss.

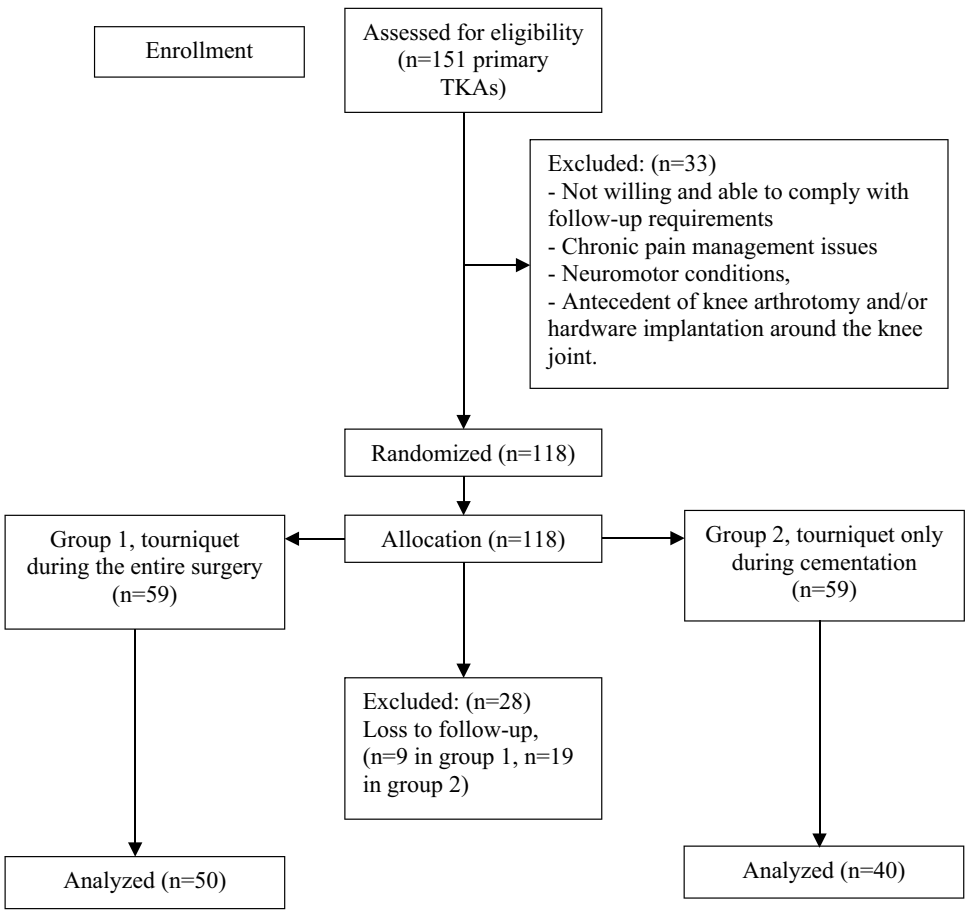

Fig. 1 Flowchart diagram. *TKA* total knee arthroplasty

Pain assessment

The pain was assessed by patient-controlled analgesia (PCA) morphine pump consumption 24 h after the surgery. Knee pain was also measured via visual analog scale (VAS) on 1–2–3 days, and 6 months after the surgery (0–10, with 10 being severe). Thigh pain was also documented.

Functional assessment

Passive range of motion (ROM) was assessed manually with a goniometer preoperatively and 1–2–3 days, and 6 months after the surgery.

The first walk, on day 1, with crutches was rated by one physiotherapist into four categories: easy, normal, difficult or impossible.

Time intervals for patients to achieve straight leg raise maneuver after the TKA, length of stay (LOS), and complications were also recorded.

Clinical scores

OKS (worst 0; best 48) was collected preoperatively and postoperatively at a follow-up of 6 months for every patient.

The difference in preoperative and postoperative Hb and Hc was used to evaluate blood loss.

Surgical technique

All operations were performed by two senior knee surgeons under general or spinal anesthesia.

A cruciate retaining mobile bearing, fully cemented TKA (Attune knee CR RP system DePuy Synthes, Warsaw, IN, USA) without patellar resurfacing was implanted through a medial subvastus approach for all cases.

The components were aligned following the mechanical alignment principles.

All patients received 1 g of IV TXA 30 min prior to the incision and intraoperative pericapsular local anesthetics injections. No nerve blocks were performed.

No suction drains were used.

After exsanguination of the leg, the tourniquet was either inflated before skin incision (group 1) or just before cementing the implant (group 2) and released before closing of the arthrotomy. The tourniquet was inflated to a pressure that was based on the systolic pressure value recorded (100 mmHg above the baseline systolic pressure).

The postoperative care included multimodal analgesia as a combination of acetaminophen, nonsteroidal anti-inflammatory agents, and tramadol.

A patient-controlled analgesia (PCA) morphine pump was placed for 24 h and the patient was trained to how to use it. The consumption was recorded. After removal of the PCA pump, the patient only received the above described multimodal analgesia. No other narcotics than tramadol were given.

With the guidance of one physiotherapist, patients were encouraged to perform exercises from day 1.

All patients received low-molecular-weight heparin at a prophylactic dose for 30 days following the surgery.

Follow-up

Clinical follow-up was done every day until their discharge from the hospital and at 6-month postoperative.

Participants, physiotherapist, statisticians, and the resident doctor in charge of the follow-up were blinded in order to enable unbiased collection and analysis of patient-reported and functional outcomes.

Statistical analysis

Descriptive statistical analysis was performed, and normality of the data was evaluated using the Kolmogorov–Smirnov test. Chi-square test was performed to compare differences between categorical variables. However, if more than 20% of cells have expected frequencies < 5, a Fisher's exact test was performed. Continuous variables were compared using an independent *t* test or the Mann–Whitney *U* test. Ordinal variables were compared using a Mann–Whitney *U* test for independent samples. All statistical analyses were conducted using SPSS software (version 28.0.1.0; IBM Corp, Armonk, NY, USA).

Statistical significance was set at $p < 0.05$.

Results

Patients' baseline characteristics were compared between the two groups (Table 1).

Except for the tourniquet time, there was no significant difference in terms of demographics, comorbidities, operative and preoperative values between the two groups.

Primary outcomes

Concerning postoperative pain, patients in group 1 (tourniquet during the entire surgery) had statistically significantly increased knee pain on postoperative day 3 ($p = 0.004$), and thigh pain on postoperative day 1 ($p < 0.001$), 2 ($p < 0.001$), and 3 ($p = 0.027$) compared to group 2 (tourniquet only during cementation). However, no significant difference in opioid consumption and knee pain on postoperative day 1–2 was observed (Table 2).

Table 1 Baseline characteristics of the studied population

Variable	Tourniquet during the entire surgery ($n=50$)	Tourniquet only during cementing ($n=40$)	p value
Age (years)	70.8 ± 8.7[a]	68.9 ± 8.8[a]	0.309
Gender (women/men)	29/21(58%/42%)	24/16 (60%/40%)	0.848
BMI (kg/m^2)	24.7 ± 4.1[a]	24.2 ± 4.8[a]	0.643
Hypertension	21 (42%)	19 (48%)	0.775
Diabetes	8 (16%)	3 (7.5%)	0.221
Rheumatoid arthritis	2 (4%)	1 (2.5%)	0.694
Preoperative Hb (g/dl)	14.1 ± 1.3[a]	14.4 ± 1.2[a]	0.377
Preoperative Hc (%)	42.1 ± 3.9[a]	42.3 ± 3.7[a]	0.742
Tourniquet time (min)	45.3 ± 9.3[a]	10.3 ± 2.1[a]	< 0.001
Laterality (left/right)	21/29 (42%/58%)	20/20 (50%/50%)	0.449
Anesthesia (general/spinal)	22/28 (44%/56%)	19/21 (47.5%/52.5%)	0.740

BMI body mass index, *Hb* hemoglobin, *Hc* hematocrit, *OKS* Oxford knee score, *min* minutes

[a]The values are given as the mean and the standard deviation

Table 2 Comparison of postoperative pain between the two groups with p values

Pain assessment	Tourniquet during the entire surgery ($n=50$)	Tourniquet only during cementing ($n=40$)	p value
PCA (mg)	14.1 ± 10.1[a]	13.9 ± 15.4[a]	0.937
K pain (VAS) PO D1	5.4 ± 2.8[a]	4.7 ± 2.6[a]	0.251
K pain (VAS) PO D2	4.1 ± 2.2[a]	3.5 ± 2.2[a]	0.197
K pain (VAS) PO D3	3 ± 1.9[a]	1.9 ± 1.5[a]	0.004
K pain (VAS) PO M6	0.2 ± 0.5[a]	0.4 ± 0.9[a]	0.225
N. of patients with thigh pain on PO D1	26 (52%)	14 (35%)	< 0.001
N. of patients with thigh pain on PO D2	19 (38%)	7 (17.5%)	< 0.001
N. of patients with thigh pain on PO D3	10 (20%)	4 (10%)	0.027

D day, *K* knee, *M* month, *N* number, *PCA* patient-controlled analgesia, *PO* postoperative

[a]The values are given as the mean and the standard deviation

About functional outcomes, no statistically significant difference was found between the two groups in terms of ROM, ability to do the first walk, and LOS.

Time intervals for patients to achieve straight leg raise maneuver was significantly longer in group 1 (2.4 ± 1.2 days vs 1.8 ± 1 days, $p=0.006$).

There was a trend but no statistically significant difference toward an easier first walk in group 2 ($p=0.055$) (Table 3).

There was no significant difference regarding surgical time (56.9 ± 9.2 min in group 1 vs 55.4 ± 4.7 min in group 2, $p=0.297$), and postoperative complications (6 in group 1 versus 4 in group 2, $p=0.294$) between the groups.

Secondary outcomes

There was no statistically significant difference in terms of 6-month postoperative knee score (45.1 ± 4.4 vs 45.1 ± 3.6, $p=0.998$), delta hematocrit (6.4 ± 3.2 vs 7.1 ± 2.9, $p=0.309$), and delta hemoglobin (2 ± 1 g/dl vs 2.3 ± 0.9 g/dl, $p=0.074$) between group 1 and 2, respectively (Table 4).

Discussion

This study was motivated by the lack of consensus and ongoing debates about the use of tourniquet for TKA. Articles with opposite conclusions can be found in the literature and authors disagree [2, 3, 13, 14].

The most important finding of this study was that limited use of a tourniquet could improve postoperative thigh pain and quadriceps function.

Diminished quadriceps strength is associated with tourniquet use for TKA [15, 16].

We came to a similar conclusion and our study showed that tourniquet has a statistically significant impact on the quadriceps. Indeed patients of group 2 were able to perform a straight leg raise maneuver earlier (group 1: 2.4 ± 1.2 days

Table 3 Comparison of the functional outcomes between the two groups with *p* values

Functional outcomes	Tourniquet during the entire surgery (*n* = 50)	Tourniquet only during cementing (*n* = 40)	*p* value
K.Ext. PO D1 (°)	11.1 ± 8.4[a]	11.5 ± 7.4[a]	0.823
K. Fl. PO D1 (°)	55.3 ± 15.3[a]	61.2 ± 14.9[a]	0.066
K.Ext. PO D2 (°)	8.5 ± 8.6[a]	7.3 ± 8[a]	0.496
K. Fl. PO D2 (°)	72.9 ± 13.3[a]	77.1 ± 10.6[a]	0.096
K.Ext. PO D3 (°)	7.7 ± 8.5[a]	6.6 ± 7.2[a]	0.505
K. Fl. PO D3 (°)	86.2 ± 9.8[a]	86.7 ± 8.8[a]	0.797
K.Ext. PO M6 (°)	0[a]	0.4 ± 2[a]	0.205
K. Fl. PO M6 (°)	124.1 ± 6.9[a]	121.7 ± 9.7[a]	0.184
Ability to achieve straight leg raise maneuver (days)	2.4 ± 1.2[a]	1.8 ± 1[a]	0.006
LOS (days)	3.8 ± 0.8[a]	3.8 ± 1.2[a]	0.981
Ability to do the first walk on PO D1 (patients)			
Easy	25 (50%)	12 (30%)	0.055
Normal	21 (42%)	18 (45%)	
Difficult	4 (8%)	7 (17.5%)	
Impossible	0	3 (7.5%)	

D day, *Ext* extension, *Fl* flexion, *K* knee, *LOS* length of stay, *M* month, *PO* postoperative

[a]The values are given as the mean and the standard deviation

Table 4 Comparison of the secondary outcomes between the two groups with *p* values

Secondary outcomes	Tourniquet during the entire surgery (*n* = 50)	Tourniquet only during cementing (*n* = 40)	*p* value
OKS	45.1 ± 4.4	45.1 ± 3.6	0.998
Postoperative Hb (g/dl)	12.1 ± 1.5	12 ± 1.2	0.647
Postoperative Hc (%)	35.6 ± 4.4	35.2 ± 3.4	0.637
Delta Hb (g/dl)	2 ± 1	2.3 ± 0.9	0.074
Delta Hc (%)	6.4 ± 3.2	7.1 ± 2.9	0.309
Surgical time (min)	56.9 ± 9.2	55.4 ± 4.7	0.297

The values are given as the mean and the standard deviation

Hb hemoglobin, *Hc* hematocrit, *OKS* Oxford knee score, (worst 0; best 48)

vs group 2: 1.8 ± 1 days) and had significantly less thigh pain on postoperative day 1–2–3 compared to group 1.

However, it did not affect overall narcotic consumption, postoperative range of motion, and ability to do the first walk. The latter keeps the tourniquet debate alive and invites us to question the benefit of not using it if the patient's functional recovery is not compromised.

Some authors showed that the use of tourniquet was not associated with either early-stage pain or 1-year postoperative functional outcomes [17]. For others, the impact on postoperative pain and opioids is minimal [18]. Finally, some studies found no difference in pain and functional outcomes [19–22].

Regarding knee pain, there was no significant difference in postoperative knee pain on day 1–2 and opioid consumption. We found that long-duration tourniquet had significantly more knee pain on postoperative day 3. The latter could be explained by the increased patient activity (longer walk, improved ROM, stairs), and soft tissue swelling, soliciting the traumatized quadriceps.

But, to the contrary of what we expected to find, there was no significant difference in postoperative ROM, ability to walk, and OKS in this study's dataset.

For many, using a tourniquet allows a better surgical field visualization [6, 7]. Therefore, we expected longer surgical time and higher blood loss in group 2. In our cohort, our hypothesis could not be validated. This could be explained by the use of TXA and local infiltration of analgesia, which significantly reduces intraoperative blood loss [23–25], therefore limiting the influence of the tourniquet between the groups.

The strengths of our study are its prospective randomized double-blinded design, its relatively large sample size, and large number of data collected. Furthermore, all patients were

followed by the same resident doctor and physiotherapist on day 1–2–3 and 6-month postoperatively, both unaware of the patients' group allocation.

Limitations of this study include the short follow-up (6 months); however, the aim of this study was to investigate the effects of a tourniquet on early postoperative pain and functional outcome. Second, in our study, the surgeons were experienced and the overall tourniquet and surgery time was short. Adverse effects of the long-duration tourniquet versus short-duration tourniquet might increase for more junior surgeons with longer surgical time. Third, this study's design allows an analysis of the impact of the tourniquet on functional outcomes and pain. However, cement penetration depth, intraoperative visibility, mid-term implant stability, etc., were not addressed.

Lastly, all TKA were implanted using a medial subvastus approach which is quadriceps sparing. We believe that using a more traumatic approach might increase adverse effects of the tourniquet by summing muscle traumatism.

Conclusion

Tourniquet use increases postoperative thigh pain and diminishes quadriceps function. It also increased knee pain on postoperative day 3. However, it did not affect overall narcotic consumption, knee pain (day 1–2), functional recovery, ROM, ability to do the first walk, OKS, LOS, or complication rate.

In our opinion, any decrease in postoperative pain is beneficial for the patient's rehabilitation process.

We, therefore, recommend limited use of tourniquet to be quadriceps sparing.

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Author's contribution Study design, BG, EM, and GB; data collection, DM and GB; data analysis, DM and GB; writing of manuscript, GB; editing of manuscript, BG, EM, DM, and GB; surgeons, BG and EM; revision and final approval of the manuscript BG, EM, DM, and GB.

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Data availability The data that support the findings of this study are available from the corresponding authors upon reasonable request.

Declarations

Conflict of interest Bernard Geulette, Eric Manche, David Mazy, and Gautier Beckers: None.

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