Late Tourniquet Release and Drain Clamping Reduces Postoperative Blood Loss in Total Knee Arthroplasty

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Abstract *Background:* Many studies have investigated the effect of tourniquet release time and closed suction drainage in total knee arthroplasty (TKA). However, controversy remains as to the advisability of preclosure tourniquet release and the advisability of closed suction drain use following total knee arthroplasty. *Questions/Purposes:* The aim of the study was to investigate if there is a benefit of performing tourniquet release after skin closure, along with drain clamping, for the first 6h following TKA. *Methods:* Ninety-six patients underwent TKA between May 2009 and April 2010. Fourteen of these were excluded because of systemic diseases and simultaneous bilateral TKA. Twenty-nine of these were excluded due to use of a patellar component and posterior cruciate ligament (PCL)-sacrificing systems. Thus, 53 patients that underwent PCL-retaining cemented TKA were reviewed retrospectively. In the control group (group C), the tourniquet was released before skin closure, an attempt at hemostasis was made, and a compressive bandage was applied. The drain was not clamped in these patients. The test group of 23 patients (group T) had tourniquet

release after skin closure and after the compressive bandage was applied. The drain was clamped for the first 6h after surgery. The two groups were compared as to the amount of drained blood, postoperative change in hemoglobin, postoperative complications, and knee function. *Results:* We found that drained blood and hemoglobin drop were significantly lower in group T compared with group C. There was no difference regarding postoperative complications and knee function. *Conclusion:* We conclude that tourniquet release after skin closure and compressive dressing followed by 6h of drain clamping reduces postoperative blood loss in TKR surgery.

Keywords total knee arthroplasty · blood lost · tourniquet release time · drain clamping and compressive bandage

Introduction

Tourniquet use is controversial in total knee arthroplasty. Some authors have advised tourniquet use to improve visualization in the surgical area and provide a bloodless field for cementing [6, 16]. However, others do not recommend tourniquet use due to probable adverse affects such as nerve injury, thromboembolism, postoperative pain, and decreased muscle strength [12, 21].

The tourniquet is commonly released before wound closure to secure homeostasis, to avoid the risk of not recognizing a major vascular injury, and for better evaluation of patellar tracking [1]. Some authors release the tourniquet after wound closure claiming no difference in blood loss and postoperative complications [7].

Using closed suction drainage after total knee arthroplasty (TKA) is also controversial. Some studies have shown that closed suction drainage prevented the formation of post-op hematomas in the knee, decreased tension on incisions, diminished delayed wound healing, and reduced the risk of infection [8, 11]. However, some studies have demonstrated that closed drainage leads to increased blood loss after TKA, because it eliminates the tamponade effect,

Level of Evidence: Therapeutic Study Level III. See “Levels of Evidence” for a complete description.

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and may cause retrograde infection [3]. In contrast to the above studies, others have reported that closed suction had no benefit in TKA [5]. Finally, some authors have recommended temporary or intermittent drain clamping in the early postoperative period [10, 24].

In this study, the effects of combined late tourniquet release and temporary drain clamping in total knee arthroplasty were investigated. We aimed to investigate if this combination of steps would be associated with (1) a lower drop in postoperative hemoglobin and (2) a smaller volume of drained blood compared to tourniquet release before wound closure and continuous closed suction drainage without drain clamping.

Materials and Methods

The study protocol was approved by the Local Ethics Committee (Gulhane Military Medical Academy Ethics Committee—2011). Informed consent was obtained from each of the study participants. Ninety-six patients with gonarthrosis underwent cemented posterior cruciate ligament (PCL)-retaining TKA by the same senior author. Forty patients had hypertension, 25 patients had heart disease, 30 patients had diabetes mellitus type 2, and all patients had been diagnosed with knee osteoarthritis clinically and radiologically. Fourteen patients were excluded because of a bleeding disorder, rheumatoid arthritis, and chronic diseases, and 29 patients were excluded due to application of a patellar replacement and PCL-sacrificing system, simultaneous bilateral TKA, and revision arthroplasty. Fifty-three patients who underwent TKA with preserved PCL were included in study. Preoperative hemoglobin of all patients was over 10hb (in grams per deciliter). Predonation of autologous blood was not performed for any patient. Nonsteroidal anti-inflammatory drugs and aspirin were stopped 1 week prior to surgery.

Of the 53 patients, 37 were female and 16 were male. Patients were similar demographically in both groups. Their mean age (66.2 vs. 63.9 years), sex (9 female–21 male vs. 7 female–16 male), height (158.5 vs. 159.6cm), weight (75.7–76.8kg), and ASA were comparable in both groups (Table 1). The length of incision was similar in both groups. Surgery time was 72.2 min in group C and 69.3 min in group T. The mean tourniquet time was 64.7 min in the control

group and 69.3 min in group T. All patients were administered with 2,000 cc fluid on the day of surgery and 1,000 cc on the postoperative first day.

All patients underwent a cemented total knee arthroplasty using Zimmer, DePuy, Aesculap implants preserving the PCL. Combined spinal and epidural anesthesia was administered to all patients. TKA was performed by midline skin incision and medial parapatellar arthrotomy under pneumatic tourniquet. For bony resection, an intramedullary alignment system was used for the femur with an extramedullary device for the tibia. Patelloplasty was applied to all patients. The intramedullary guide holes in the distal femur were plugged with autologous bone graft in each patient before inserting the components.

In the control group (group C), the tourniquet was deflated when the cement had hardened; then, homeostasis was attempted and the compressive dressing was applied. The subcutaneous tissue and skin were then closed. In the test group (group T), the tourniquet was deflated after the wound had been closed and the compressive dressing applied. A compressive bandage was applied using two layers of cotton wool and two layers of elastic bandage in both groups. The drain was placed within the knee joint at the end of surgery in all patients of both groups. The drains were clamped for the first 6h after surgery in group T, and no clamp was applied in group C. Drains were removed 24h after surgery in all patients. Ice treatment was performed 10 min/2h at the first 24h postoperatively. All patients had the same rehabilitation program. Isometric exercises and active ankle dorsiflexion were started immediately after surgery. All patients had continuous passive motion (CPM) with ROM of 0° to 90° and were allowed walking 1 day postoperatively.

Enoxaparin (Aventis Pharma International) was injected for antithrombotic prophylaxis subcutaneously. The dose was 0.2 ml preoperatively and on the day of surgery, then 0.4 ml once a day for 2 weeks postoperatively. Antibiotic prophylaxis was administered using first-generation cephalosporin at a dose of 1 g within 1h of surgery and 1 g per 12h after surgery until 72h postoperatively. Drains were taken out at 24h after surgery routinely. Drained blood was measured two times (per 12h) and registered by a nurse, and the total amount of drained blood was confirmed independently by the duty resident. Hemoglobin levels were measured at 1 week preoperatively and at 48h after surgery in all patients (Automatic LH 780 Hematology Blood Analyzer from Beckman Coulter). The amount of drained blood and drop of hemoglobin levels were compared between the two groups.

Table 1 Patient demographics and surgery details of the two groups

	Control group	Study group
Number of patients	30 (100%)	23 (100%)
Male	9 (30%)	7 (28%)
Female	21 (70%)	16 (72%)
Average age	66.2	63.9
Mean weight (kg)	75.7	76.8
Mean height (cm)	158.5	159.6
ASA	1 = 3(10%) 2 = 30(90%)	1 = 2(8.7%) 2 = 21(91.3%)
Length of incision (cm)	15.8	16.1

Data Analysis

Statistical analyses were performed with SPSS statistical software (SPSS for Windows, ver. 15.0; SPSS, Chicago, IL). All data were expressed as mean $\pm$ SD, frequency, and percentage. The distribution of the groups was analyzed with the Kolmogorov–Smirnov one-sample test. The volume of drained blood and preoperative and postoperative hb were compared using Student's *t* test. A level of $P < 0.05$ was accepted as statistically significant.

Table 2 Volume of drained blood at 24h and hemoglobin drop at 48h in both groups

	Control group	Study group	P value
Volume of drained blood (ml)	580.0±122.2	108.3±83.8	<0.001
Pre-op hemoglobin (g/dl)	13.2±1.2	13.0±1.6	0.616
Post-op hemoglobin (g/dl)	11.0±1.1	11.9±1.8	0.044
Surgery time (min)	74.2±5.4	69.3±6.2	0.039
Tourniquet time (min)	62.7±4.7	69.3±5.8	0.033

Results

Group C experienced greater blood loss via the drain than group T ($P=0.001$). The volume of drained blood was 580.0±122.2 ml in group C and 108.3±83.8 ml in group T. There was no difference in the preoperative hemoglobin value between the groups, but the postoperative hemoglobin of the control group was lower than that of the study group statistically ($P=0.044$) (Table 2).

Allogenic blood transfusion was required for two patients in the control group and for no patient in the study group. Two patients in the study group developed mild hematoma, but this did not require any special treatment nor delayed the hospital discharge or physical therapy protocol.

Discussion

The aim of the present study was to investigate the effects of combined tourniquet release after skin closure and closed drain suction with temporary 6h of drain clamp measuring hemoglobin level and amount of drained blood after TKA. We found that tourniquet release after skin closure and temporary drain clamping reduced drained blood compared to tourniquet release before wound closure and closed suction without drain clamping.

The study has some limitations. The first limitation is the small number of patients, but nonetheless, we found a difference in the measured variables between groups. Secondly, this was a prospective comparative study, but the patients were not randomized to the study groups suggesting there may be uncontrolled bias affecting the results.

Routinely, the tourniquet is released after the cement has hardened, and bleeding control is performed to reduce postoperative blood loss. Larson et al. [13] reported that capillary and medullar bleeding increased in the early period after tourniquet release due to reactive blood flow. So, some authors have thought that the release of the tourniquet after skin closure might be effective. Therefore, there are many studies in literature which have been conducted to investigate the effect of tourniquet release time, with reports of different results regarding blood loss and complications (Table 3) [4, 9, 14, 16, 21–23]. In the current study, tourniquet release after skin closure decreased postoperative blood loss significantly. Only two patients in the late tourniquet release group had hematoma, which was not significant clinically or for rehabilitation.

A wide closed space occurs during TKA, which, if not drained, leads to theoretical risks of hematoma and infection [2, 18]. The use of drainage has been believed to be effective in decreasing hematoma formation, which theoretically has been thought to decrease postoperative pain, swelling, and incidence of infection. However, routine postoperative drainage especially with closed suction may increase the blood loss due to lack of tamponade effect [17]. Concerns about increased blood loss by postoperative drainage may be eliminated with various drainage methods. These different methods include intermittent or temporary drain clamping. Therefore, a temporary hematoma which forms after a period of clamping has the effect of a tamponade in the early postoperative period. Some authors prefer to inject saline with or without adrenalin before drain clamping [19]. Others prefer not to inject saline due to concerns about infection, and they do not believe in the effectiveness of adrenaline [10–20]. We have not used this approach as we do not believe this volume of saline can provide a tamponade effect and because of the perceived risk of infection.

The recommended time for drain clamping is unclear. Larsson et al. [13] reported that when the tourniquet was released, reactive blood flow increased with the peak flow appearing within 5 min. However, some authors have claimed that a longer clamping time is more effective in decreasing blood loss. Yamada et al. [24] showed that a 24-h clamping period is more effective than 1-h clamping time in terms of blood loss. However, they reported that the complication rate in the 24-h group was high (22.7%), and the study was stopped. Prasad et al. [15] compared 1-h clamping with a 2-

Table 3 Results of the studies regarding tourniquet release time in TKA

Study	Years	No. of knees	Measure	Results
Page et al.	1984		Demand blood transfusion, drained blood	— ^a
Steffin et al.	2009	37	Htc, drained blood	— ^b
Widman et al.	1999	85	Drained blood	— ^b
Thorey et al.	2008	40	Perioperative blood loss, postoperative complications	— ^b
Christodoulou et al.	2004	80	Demand blood transfusion, drained blood	— ^{a, c}
Ishii et al.	2005	60		— ^a
Rama et al. (meta-analysis)	2007	893		— ^{a, c}

^a Tourniquet release before skin closure reduces blood loss in TKA

^b Tourniquet release time was not important to reduce blood loss in TKA

^c Increased postoperative complications

hourly intermittent clamping group. They concluded that 2-hourly intermittent clamping reduced blood loss in the drain. They also found that 2-hourly intermittent clamping is effective, especially in the first 8h. It has been shown that most blood loss in TKA occurs during the first few postoperative hours (37% in 2h and 55% in 4h) [2–17]. Therefore, it is logical that the first 4–6h of drain clamping after tourniquet release can temporarily recreate a tamponade effect for bleeding control and avoid serious adverse effects. Thus, in the current study, 6h of temporary drain clamping was used.

In conclusion, the results of this study show that tourniquet release after skin closure and 6h of temporary drain clamping results in less blood loss than tourniquet release after cement hardening with attempted hemostasis and conventional drain technique. There was no increased risk for postoperative complications regarding infection, thromboembolism, delayed rehabilitation, or discharge from hospital.

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Disclosures

Conflict of Interest: Kenan Koca, MD, Cemil Yildiz, MD, Necmettin Kocak, MD, Servet Tunay, MD, and Mustafa Basbozkurt, MD, have declared that they have no conflict of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was obtained from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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