Original Article

Subcutaneous versus intraarticular closed suction indwelling drainage after total knee arthroplasty
A randomised control trial

Jae-Hyuk Yang, Jung-Ro Yoon, Anshul Dahuja, Seungyeop Song

Abstract

Background: Total knee arthroplasty (TKA) is widely accepted treatment for moderate or severe osteoarthritis and rheumatoid arthritis. Significant blood loss can be seen during the early postoperative period where a blood transfusion may be necessary. Closed suction drainage is known to prevent the formation of hematomas in the operative field, decrease tension on incisions, diminish delayed wound healing and reduce the risk of infection. Subcutaneous indwelling closed suction drainage method has been known to be beneficial and an alternative to the intraarticular indwelling method. This prospective randomized study was to compare the visible, hidden, total blood loss and postoperative hemodynamic change of subcutaneous and intraarticular indwelling closed suction drainage method after TKA.

Materials and Methods: One hundred and sixty patients with primary osteoarthritis who underwent unilateral TKA were enrolled; group A with subcutaneous (n = 78) and group B with intraarticular (n = 79) indwelling closed suction drainage method. Total blood loss, visible blood loss, internal blood loss, postoperative day 1, 5th, 10th day hemoglobin, hematocrit levels were compared. Allogeneic blood transfusion rate and complications related to soft tissue hematoma formation were additionally compared.

Results: Allogenic transfusion requirements between subcutaneous drainage group and intraarticular drainage groups (6.4% vs. 24.1%) were significantly different (P = 0.002). Although the minor complications such as the incidence of bullae formation and the ecchymosis were higher in the subcutaneous indwelling group, the functional outcome at postoperative 2 year did not demonstrate the difference from intraarticular drainage group.

Conclusion: Subcutaneous indwelling closed suction drainage method is a reasonable option after TKA for reduction of postoperative bleeding and transfusion rate.

Key words: Blood loss, closed suction, drainage system, subcutaneous, total knee arthroplasty
MeSH terms: Arthroplasty, replacement, knee, blood loss, postoperative, drainage, suction

Introduction

Total knee arthroplasty (TKA) is widely accepted treatment for moderate or severe osteoarthritis and rheumatoid arthritis. Significant blood loss can be seen during the early postoperative period where a blood transfusion may be necessary. However, it has been known that the donor blood may lead to an immunological reaction and the transmission of viral infections (e.g., hepatitis and AIDS).[1]

Various methods have been suggested to reduce blood loss following TKA, such as preoperative erythropoietin and iron supplementation, autotransfusion,[2,3] postoperative blood salvage,[4] hypotensive anesthesia,[5] tranexamic acid administration,[6] intraarticular epinephrine injection,[7] thrombin based hemostatic agent,[8] and temporary drain clamping.[9,10]

Closed suction drainage is known to prevent the formation of hematomas in the operative field, decrease tension on incisions, diminish delayed wound healing and reduce the risk of infection.[11] However, some studies have demonstrated that closed drainage leads to increased blood loss after TKA because it eliminates the tamponade effect and may cause a retrograde infection.[12] The role of wound drainage following knee arthroplasty is still controversial.[13,14] Despite these disagreements, wound drainage is a procedure widely

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used by orthopedic surgeons and it is still assumed to be a standard of care and suggested for use in TKA.

Subcutaneous indwelling closed suction drainage method has been known to be beneficial and an alternative to the intraarticular indwelling method.[15] This method provides tamponade effect as the joint is not drained and in addition has subcutaneously drainage effect preventing the soft tissue hematoma and wound problems. The purpose of this prospective randomized study was to compare the visible, hidden, total blood loss and postoperative hemodynamic change of subcutaneous and intraarticular indwelling closed suction drainage method after TKA. The hypothesis was that subcutaneous indwelling method would decrease the visible, total blood loss and reduction of postoperative hemoglobin (Hb) or hematocrit (Hct) change after TKA.

Materials and Methods

160 patients with primary osteoarthritis, who underwent unilateral TKA in our institute between January 2011 and September 2011, were enrolled in this trial. All patients were randomly assigned into two groups (80 per group) using computer-generated numbers. The sample size was calculated to detect a significant difference in the postoperative drainage and laboratory change between groups with a power of 80% with an α value of 0.05. Group A and B were patients with subcutaneous and intraarticular indwelling closed suction drainage method, respectively. Three patients have been lost in the followup. This left 157 TKAs (78 patients for Group A and 79 patients for Group B) who form the basis of the current report [Figure 1]. Exclusion criteria include other diagnosis than primary osteoarthritis, preoperative valgus alignment, received a revision or bilateral TKA, hematological disease, previous open knee surgery or vascular surgery. There were 53 males and 104 females with an average age of 69.5 ± 5.8 years (range 61-82 years), and the average body mass index was 24.9 ± 4.7 kg/m^2 [Table 1]. This study was conducted after the approval of the Institutional Review Board and informed consent was obtained from each patient before enrollment in the study.

All surgeries were performed by a single surgeon (JHY) using the navigation system (OrthoPilot™, version 4.0; B. Braun Aesculap, Tuttlingen, Germany) under spinal anesthesia. All 160 knees underwent the same surgical approach consisting of a midline skin incision and a medial parapatellar approach under tourniquet. All patients were implanted with cemented type ultra-congruent fixed bearing design (Columbus™ UC, B. Braun Aesculap, Tuttlingen, Germany). None of the patients underwent lateral retinacular release or patellar resurfacing.

In the subcutaneous indwelling group (Group A), a vacuum drainage system was placed in the subcutaneous space (below the medial skin flap) after joint capsule closure [Figure 2].[15] In the intraarticular indwelling group (Group B),

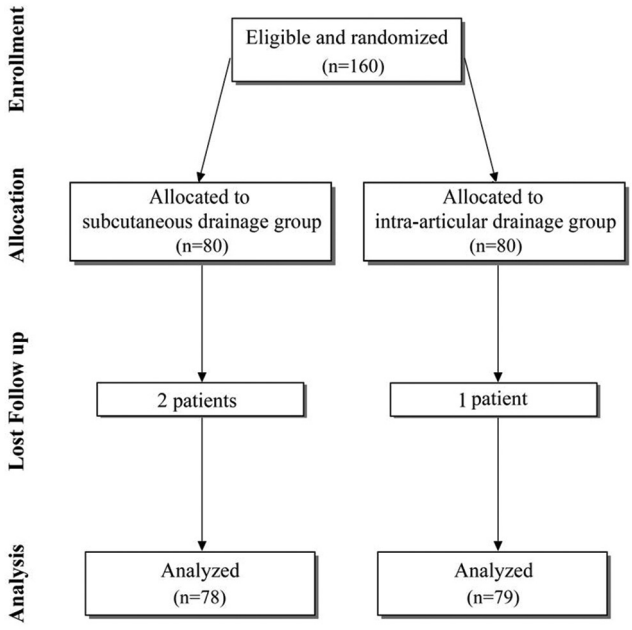

Figure 1: Flow char showing consolidated standards of reporting trials

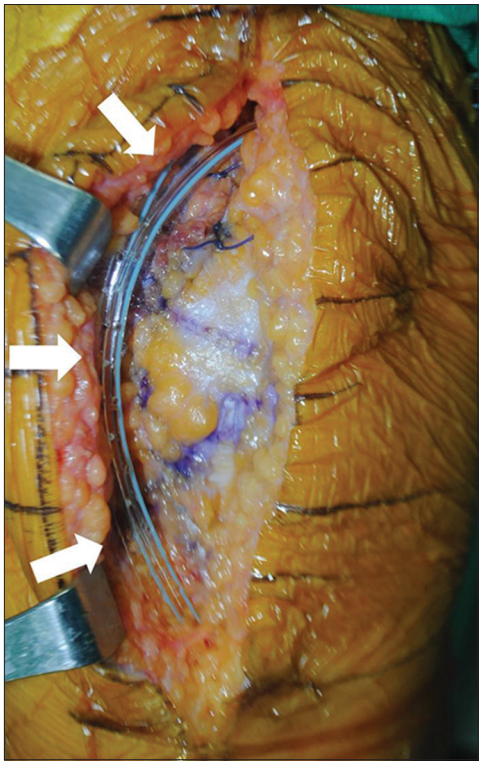

Figure 2: Subcutaneous indwelling closed suction drainage method. Note that the indwelling drains (white arrows) are placed subcutaneously superficial to the joint capsule closure

Table 1: Patient demographics, preoperative deformities and functional status

Variables	Group A (*n*=78)	Group B (*n*=79)	*P*
Ratio of male:female patients	27:51	26:53	NS
Age (years)	68±6.6	69±4.5	NS
Height (cm)	168±4.2 (for males), 158±3.6 (for females)	169±3.2 (for males), 156±3.2 (for females)	NS
Weight (kg)	70±5.1 (for males), 52±3.4 (for females)	74±5.5 (for males), 54±3.1 (for females)	NS
Preoperative flexion contracture (°)	7.1±6.5	5.2±5.7	NS
Preoperative further flexion (°)	130.5±12.2	130.3±10.2	NS
Preoperative mechanical axis angle (°)	−8.8 (varus) ±2.1	−7.8 (varus) ±3.1	NS
Mechanical tibial angle (°)	85.2±3.4	87.4±1.4	NS
Mechanical femoral angle (°)	87.5±4.4	87.7±5.4	NS
Preoperative KSS knee score	52.4±6.8	54.5±7.4	NS
Preoperative KSS functional score	64.4±8.2	65.6±7.7	NS
Preoperative WOMAC pain	10.2±2.1	10.5±3.0	NS
Preoperative WOMAC stiffness	4.2±2.0	4.4±2.1	NS
Preoperative WOMAC function	38.6±4.1	40.5±5.3	NS

All values are mean±SD except male-female ratio. NS=No significance, KSS=Knee Society Score, WOMAC=Western Ontario MacMaster, SD=Standard deviation

a vacuum drainage system was placed in the intraarticular space (the medial gutter) before joint capsule closure. All drains were kept open constantly without clamping. The amount of drained visible blood was recorded at 24 and 48 h using the measuring cylinder with total 500 mL and 1.0 mL unit. All suction drains were removed 48 h postoperatively. Using Gross's formula,[16] hidden blood loss was calculated using patients' height, weight, and preoperative and postoperative Hct. The Hb and Hct levels were determined preoperatively and 12 h (day 1), 5th and 10th day postoperatively. The patients received packed red blood cells if their Hb levels decreased to <8 g/dL and presents compromised clinical criteria (e.g., tachycardia, hypotension, or symptoms of anemia that were relative to the preoperative medical condition of the patient) necessitated transfusion. The postoperative timing of transfusion and the number of units of transfused red blood cell concentrates were recorded. All patients were given low molecular weight heparin (Enoxaparin 40 mg) subcutaneously daily for 7 days postoperatively.

After the operation, patients of both groups were encouraged to perform a mechanical ankle pumping exercise to prevent deep vein thrombosis as soon as possible after surgery. The bandage and Foley's catheter were removed on the second postoperative day. On the same day, the range motion (ROM) exercise using continuous passive motion devices, an isometric/isotonic quadriceps exercise, a straight leg rising exercise and a walking exercise were initiated under the control of a physiotherapist.

All the observations were recorded by clinical research orthopedic nurse who was unaware about the allotted groups. The possible adverse issues with subcutaneous drainage and wound problems were analyzed. Oozing persisting beyond 2 days after surgery, subcutaneous hematoma (requiring aspiration or surgical drainage), hemarthrosis (requiring aspiration or surgical drainage), ecchymosis (larger than 3 cm in diameter) and wound infection (requiring additional treatments such as antibiotics coverage or surgical debridement) were recorded. Thigh and calf circumference were checked at day 7 after TKA. The level for thigh circumference was set at 10 cm proximal from the patella upper pole and largest diameter for calf. These values were compared with the preoperative state.

Symptom severity was assessed at 24 months using the Knee Society Score (KSS)[17] and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score.[18] Passive maximum knee ROM was measured using a goniometer. At these evaluations, assessments were performed by a physician assistant not directly involved in the surgical procedures. A KSS of 90 points was considered an excellent outcome, a score between 80 and 89 points was considered a good outcome, a score between 70 and 79 points was considered a fair outcome and a score of <70 points was considered a poor outcome. The WOMAC system involves the completion of a 24-item questionnaire with three sections: Namely; pain, stiffness and function.[18] Five response options are possible (none, mild, moderate, severe and extreme), which are scored from 0 to 4 to yield subtotal scores for pain (5-item; possible total score range 0–20), stiffness (2-item; possible score range 0–8), and function (17-item; possible score range 0–68).

The two study groups were compared with respect to blood volumes collected via indwelled drains, changes in Hb/Hct levels postoperatively, requirements for allogeneic blood transfusion, bleeding-related wound problems, and postoperative hospital stay. The Kolmogorov–Smirnov test was used to determine whether continuous variables were normally distributed. Fisher's exact test or the Yates Chi-square test was used to analyze categorical

variables. Student's *t*-test was used to analyze continuous variables. The complication rate between the two groups was determined by the Chi-square test with Fisher's exact test. The Statistical Package for Social Science Version 10.1 (SPSS Inc., Chicago, IL, USA) was used for all analysis and $P < 0.05$ was considered statistically significant.

Results

There were no significant differences between the subcutaneous drainage group (Group A) and intraarticular drainage group (Group B) regarding the preoperative demographs [Table 1].

The total blood loss after TKA was significantly different between two groups ($P = 0.04$). The total blood loss (visible drained blood + hidden loss) was less in subcutaneous drainage group. The mean visible blood drainage in subcutaneous drainage group was significantly less than intraarticular drainage group, both during the first 24 h and between 24 and 48 h ($P < 0.001$). The hidden blood loss after TKA was significantly different between two groups ($P < 0.001$) [Table 2]. There was more hidden blood loss in the subcutaneous group (Group A).

There were no significant differences in Hb or Hct level in 2 groups before the surgery. However, significant differences of change of Hb were demonstrated between groups at 12 h (day 1), 5th and 10th day postoperatively [Table 2]. Allogeneic transfusion requirements between patients in the subcutaneous drainage and intraarticular drainage groups (6.4% versus 24.1%) were significantly different ($P = 0.002$, Table 3).

In terms of wound problems [Table 4], none of the patients developed delayed wound healing with skin edge necrosis, wound infection, deep vein thrombosis in this study. No patient in either group underwent additional surgery for any reason. However, subcutaneous drainage group (Group A) demonstrated a higher rate of minor complications such as the bullae formation and ecchymosis compared to intraarticular drainage group. There was significant increase in both thigh and calf circumference in subcutaneous drainage group. Mean postoperative hospital stay in group A and group B was 13.8 and 14.1 days, respectively ($P > 0.05$).

There were no significant differences between groups in functional outcomes at 2 year after surgery [Table 5]. Differences in postoperative flexion contracture or ROM were not found.

Table 2: Comparison of hematologic data

Variables	Group A (*n*=78)	Group B (*n*=79)	*P*
Total blood loss (mL)	663±161	1101±398	0.04
Hemovac drainage (in 0-24 h) (mL)	154±78	602±238	<0.001
Hemovac drainage (in 24-48 h) (mL)	56±38	181±120	<0.001
Hidden blood loss (mL)	500±260	273±271	<0.001
Preoperative Hb	12.56±1.47	12.21±1.46	NS
Preoperative Hct	35.67±5.18	35.31±4.24	NS
Postoperative day 1 Hb	11.1±1.51	10.1±1.39	0.05
Postoperative day 1 Hct	33.54±4.38	31.21±4.19	0.03
Postoperative day 5 Hb	8.8±1.60	8.2±2.11	0.04
Postoperative day 5 Hct	32.21±3.98	31.11±4.01	NS
Postoperative day 10 Hb	8.7±1.54	8.0±1.89	0.04
Postoperative day 10 Hct	31.38±4.76	30.23±4.29	NS

All values are mean±SD. NS=No significance, Hb=Hemoglobin (g/dL), Hct=Hematocrit (%), SD=Standard deviation

Table 3: Comparison of transfusion rate and the units

Variables	Group A (*n*=78) (%)	Group B (*n*=79) (%)	*P*
Allogeneic blood transfusion	5 cases (6.4)	19 cases (24.1)	0.002
PRBC transfusion (unit)	1.6±0.5	2.4±0.7	0.03

PRBC=Packed red blood cell

Discussion

The most important finding of this study was that subcutaneous indwelling closed suction drainage method

Table 4: Comparison of bleeding-related wound problems, change of thigh-calf circumferences and postoperative hospital stay

Complications	Group A (*n*=78) (%)	Group B (*n*=79) (%)	*P*
Skin edge necrosis	0 (0)	0 (0)	NS
Infection	0 (0)	0 (0)	NS
Deep vein thrombosis	0 (0)	0 (0)	NS
Oozing	4 cases (5)	5 cases (6)	NS
Bullae formation	20 cases (26)	1 case (1)	<0.001
Ecchymosis	24 cases (31)	5 cases (6)	<0.001
Increase of thigh circumference (cm)*	3.1±1.3	1.6±1.0	0.02
Increase of calf circumference (cm)*	2.1±1.2	1.2±1.2	0.03
Postoperative hospital stay (days)	13.8±1.1	14.1±1.3	NS

*Mean±SD. NS=No significance, SD=Standard deviation

Table 5: Comparison of postoperative functional outcomes

Postoperative 2 years outcome	Group A (*n*=78)	Group B (*n*=79)	*P*
Flexion contracture (°)	3.0±1.4	2.5±2.3	NS
Maximum further flexion (°)	125±9.5	128±8.7	NS
Postoperative KSS knee score	93.2±3.4	92.5±3.1	NS
Postoperative KSS functional score	90.2±2.1	89.7±4.1	NS
Postoperative WOMAC pain	4.2±3.0	4.5±1.2	NS
Postoperative WOMAC stiffness	1.6±0.8	1.8±1.0	NS
Postoperative WOMAC function	16.5±3.1	17.3±2.1	NS

All values are mean±SD. NS=No significance, KSS=Knee Society Score, WOMAC=Western Ontario MacMaster

reduces both the visible blood loss and total blood loss (hemovac drainage + internal blood loss) thus decreases the rate of allogeneic transfusion. Although the incidence of minor complications such as the bullae formation and the ecchymosis were significantly higher in the subcutaneous indwelling group, the functional outcome at postoperative 2 years did not demonstrate the difference from intraarticular drainage group.

A few studies have shown that closed negative pressure drainage is beneficial to early knee function recovery by reducing postoperative hematoma formation in the wound, relieving wound tension, preventing complications including pain and poor healing and lowering the incidence of deep infections.[19] However, a number of other studies have not supported the advantages of closed negative pressure drainage and indicated that closed negative pressure drainage causes complications such as postoperative hemorrhage, increased blood transfusion and infection and affects the ability of postoperative functional training.[12,20,21] The use of vacuum drainage in TKA to manage bleeding continues to be debated. Because most of the blood loss in TKA occurs during the first few postoperative hours (37% in 2 h and 55% in 4 h), it seems reasonable to clamp the drain tube in the first few hours after TKA to temporarily create a tamponade effect for bleeding control. Several studies recommended clamping method, but with variable recommendations. Recommendations included no clamping,[22] clamping for 1 h,[23] 10-min clamp releases every 2 h,[24] and clamping for 4 h.[10] The effect of clamping method is also in controversy.

The method of subcutaneous indwelling closed suction drainage had been proposed as a potentially efficacious alternative to either intraarticular closed suction drainage or no drainage system.[15] This method was suggested to exploit the advantages of both methods; the subcutaneous blood drainage and the joint tamponade effect. Seo *et al*.[15] have shown that subcutaneous closed suction drainage involves equivalent blood loss with comparable wound problems and functional outcomes compared with intraarticular closed suction drainage. However, only exogenous blood loss was analyzed in their study while internal blood loss (i.e., total blood loss) was calculated in this study. In addition, detailed postoperative minor complications were identified using the parameters such as the change of thigh and calf circumference.

The occurrence of bullae formation and ecchymosis were significantly higher in subcutaneous indwelling closed suction drainage group in this series. Although some studies have demonstrated no statistically significant difference in hematoma formation with or without postoperative drainage, TKA patients without drainage system theoretically have a higher chance of hematoma formation. While pressure dressing reduces superficial bleeding at the incision, it is less effective on bleeding in deep locations such as the marrow and periprosthesis space, which can result in invisible blood loss and hematoma formation due to blood accumulation.[25] After TKA, because the capsule of the knee joint is damaged and the surrounding soft tissue has been incised, the blood infiltration can extend to the fascia and intramuscular space of the thigh and calf, which results in increase in thigh calf circumference and ecchymosis. Subcutaneous indwelling closed suction drainage method may not be a perfect solution to prevent soft tissue accumulation from excessive blood infiltration. Despite significantly increased minor wound problems and increased thigh-calf circumference compared to intraarticular drainage group, two groups had similar functional outcome at 2 years postoperatively. Soft tissue swelling around the knee joint in subcutaneous indwelling closed suction drainage group might have reduced the ROM shortly after the operation, but it did not influence the motion arc in the long run.

Limitation of this study are methods used regarding the drainage system in TKA, subcutaneous indwelling closed suction method was compared with only the intraarticular indwelling drainage method. A group without closed suction drainage system or groups of various clamping methods have not been compared. Therefore, conclusions cannot be made whether subcutaneous indwelling closed suction drainage method has advantages or disadvantages from other methods.

Conclusion

Subcutaneous indwelling closed suction drainage method in TKA reduces total blood loss and thus lowers the rate of allogeneic blood transfusion compared to the intraarticular indwelling drainage method. Although the incidence of minor wound problems such as bullae formation and ecchymosis is higher than the intraarticular indwelling drainage method, eventual motion arc and functional outcome are similar. Based on these results, subcutaneous indwelling closed suction drainage method is a reasonable option after TKA.

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