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Original Research

Does Intramedullary Reaming in Total Knee Arthroplasty Increase Postoperative Bleeding? A Propensity Score–Matched Cohort Study

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ABSTRACT

Background: There is conflicting evidence about whether avoiding medullary canal reaming of the femur during total knee arthroplasty (TKA) reduces blood loss. This study aimed to test the hypothesis that total blood loss would decrease in TKA without medullary canal reaming.

Method: This propensity score–matched cohort study included 349 patients, of whom 220 underwent TKA using a femoral intramedullary rod, and 129 underwent TKA using a computer-assisted system without a femoral intramedullary alignment system. For the proximal tibia resection, an intramedullary alignment system was not used in any of the patients. These patients were matched using a one-to-one propensity score method. The primary outcome was perioperative blood loss, calculated from patient blood volume and the difference in hemoglobin levels from preoperative to postoperative measurements.

Results: Compared with 118 propensity score–matched patients undergoing TKA with medullary canal reaming of the femur, perioperative blood loss at 1, 3, and 7 days postoperatively was not significantly different in the 118 matched patients undergoing TKA without medullary canal reaming. In addition, no significant differences were observed in the requirement for allogeneic transfusion or the occurrence of deep venous thrombosis.

Conclusions: Postoperative blood loss did not differ between patients who underwent TKA with femoral intramedullary reaming and those without. This study supports the notion that surgeons can use familiar surgical techniques, including conventional intramedullary rods, without the need for specialized instrument, even for patients at high risk of allogeneic transfusion.

Introduction

A considerable amount of bleeding is expected during total knee arthroplasty (TKA), and blood transfusion may sometimes be necessary [1]. Allogeneic blood transfusion carries risks, such as transfusion-transmitted infections and post-transfusion graft-versus-host disease [2]. In addition, it has been proven that allogeneic blood transfusion during the perioperative period of TKA is an independent risk factor for periprosthetic joint infections and deep vein thrombosis (DVT) [3-5]. Therefore, it is important to reduce blood loss during the perioperative period of TKA.

The procedure using an intramedullary rod is the most common method for distal femur resection to place the femoral component during TKA [6]. In this method, the articular surface of the distal femur is drilled, followed by reaming of the medullary canal, and an intramedullary rod is inserted to determine the placement angle of the femoral component based on the femoral axis [7]. Reaming the medullary canal may increase postoperative bleeding. Previous studies, however, have shown conflicting results, with some indicating a reduction in postoperative bleeding by avoiding medullary canal reaming [8,9], while others found no significant difference [10,11].

The purpose of this study was to investigate whether there would be a difference in postoperative blood loss depending on the absence of medullary canal reaming. The hypothesis of this study was that total blood loss would be reduced in TKA without medullary canal reaming.

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Material and methods

This retrospective study was performed following institutional review board approval. It included a consecutive series of 648 patients who underwent TKA between January 2020 and December 2022 (Fig. 1). We excluded 143 patients with 286 knees who underwent simultaneous bilateral TKA, 7 patients who underwent revision TKA, and 6 patients who underwent single-anesthetic TKA and total hip arthroplasty (n = 6). In 220 TKAs, distal femur resection was performed using an intramedullary rod (intramedullary rod group), while in the remaining 129 TKAs, a navigation system was used without medullary canal reaming of the femur (computer-assisted surgery [CAS] group). The decision to use navigation and the choice of a specific navigation system for each patient were left to the surgeon's discretion. Therefore, there were no established criteria for its use during the study period. Proximal tibia resection was performed without an intramedullary alignment system in all TKAs.

The primary outcome was the volume of perioperative blood loss, which was determined on the basis of the blood volume as computed using the formula of Nadler et al. [12] and the change in hemoglobin from the preoperative to postoperative stage [13]. The secondary outcomes were the number of patients requiring allogeneic blood transfusion and the incidence of DVT.

Surgical technique

All surgeries were performed or supervised by a single surgeon (ST). A posterior-stabilized implant was used in all patients, with both the femoral and tibial components fixed using cement. A tourniquet was not used in any of the surgeries, and intravenous tranexamic acid was administered in all cases.

In the Intramedullary rod group, distal femur resection was performed using a conventional intramedullary rod. After drilling into the medullary canal, the rod was inserted into the canal (Fig. 2). Following resection of the distal femur, the insertion point was plugged by impacting the resected cancellous bone.

In the CAS group, distal femur resection was performed using a navigation system. The navigation systems used in this study were the KneeAlign2 (OrthoAlign, Aliso Viejo, CA) and the AR-Knee (Zimmer Biomet Japan, Tokyo, Japan). Both systems involved inserting a pin or keel to attach the navigation device to the distal femoral joint surface, without manipulating the femoral medullary canal [14].

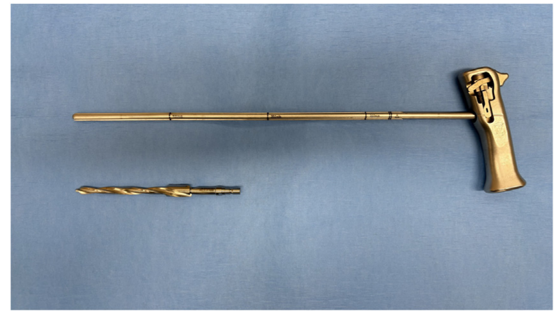

Figure 2. Appearance of the 8.0-mm intramedullary rod and the intramedullary step drill. The 8.0-mm fluted intramedullary rod is inserted to a depth of 200–280 mm into the femoral intramedullary canal after drilling the distal femur up to the larger diameter section of the intramedullary step drill.

Sample size calculation and statistical analysis

We considered a reduction of 100 mL in total blood loss within 3 days after TKA to be a clinically relevant difference. We required 99 patients per group to detect a mean difference (and standard deviation) of 100 ± 250 mL in total blood loss, with a two-sided 5% significance level and 80% power. For the power analysis, we used a standard deviation of 250 mL in total blood loss at 3 days after TKA based on data from a previous study including postoperative unilateral TKA patients [13].

Patients in the intramedullary rod group were matched 1:1 to those in the CAS group based on the logit of propensity scores, using a caliper of 0.2 times the standard deviation. Patients' age, sex, body mass index, and preoperative hemoglobin level were included as covariates for the propensity score calculation. Standardized mean differences for all covariates were estimated before

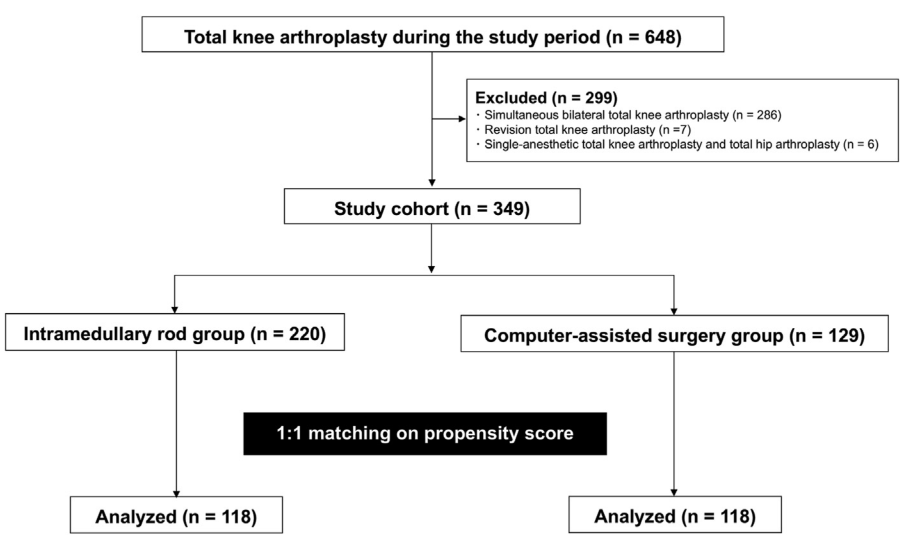

Figure 1. Selection of patients for inclusion in the study comparing unilateral primary total knee arthroplasty with and without femoral intramedullary reaming in terms of postoperative blood loss.

Table 1
Patient demographic and baseline clinical characteristics before matching.

Characteristic	Intramedullary rod group (n = 220)	Computer-assisted-surgery group (n = 129)	*P*-value	Standardized mean difference
Age, years	75 ± 7	74 ± 8	.58[a]	0.060
Sex (female/male)	197/23	102/27	.011[b]	0.291
Height, cm	151 ± 7	152 ± 7	.28[a]	0.119
Weight, kg	62 ± 11	63 ± 12	.85[a]	0.021
Body mass index, kg/m^2	27.2 ± 4.3	27.0 ± 4.3	.63[a]	0.053
Preoperative hemoglobin level, g/dL	12.9 ± 1.4	13.2 ± 1.4	.048[a]	0.221

Results are expressed as means ± standard deviation, unless otherwise indicated.
[a] *P*-values were determined with Student's *t* test.
[b] *P*-values were determined with chi-squared test.

and after matching, with a standardized mean difference of 10% or more indicating imbalance.

After matching, we compared total blood loss between the 2 matched cohorts as the primary outcome using Student's *t*-test. A *P*-value of <.05 was considered statistically significant. For secondary outcomes and baseline characteristics, continuous measures were presented as means with standard deviations and compared using the Student's *t*-test. Dichotomous data were compared using the chi-squared test.

All analyses were conducted using the R statistical package (version 4.3.1; R Foundation for Statistical Computing).

Results

Matching

Before conducting propensity score matching, a comparison of patient characteristics between the 2 groups revealed significant differences in sex and preoperative hemoglobin levels (Table 1). We successfully matched 118 patients in the CAS group with 118 patients in the intramedullary rod group. After matching, the absolute standardized mean differences for all variables included in the propensity score were less than 0.1, indicating an adequate match (Table 2).

Outcomes before and after matching

Table 3 summarizes the postoperative total blood loss after TKA for all patients during the study period (before propensity score matching). On postoperative day 3, the total blood loss was significantly lower in the CAS group than that in the intramedullary rod group (522 ± 281 mL vs 586 ± 271 mL; 95% CI for the difference, 3-125 mL; *P* = .039). Allogeneic blood transfusion was required in 2 of 129 patients in the CAS group and 2 of 220 patients in the intramedullary rod group (*P* = .63). DVT occurred in 4 of 129 patients in the CAS group and 11 of 220 patients in the intramedullary rod group (*P* = .71).

Table 4 shows the postoperative total blood loss after TKA following propensity score matching. There were no significant differences between the 2 groups in terms of total blood loss. Allogeneic blood transfusion was required in 2 of 108 patients in the CAS group, and no patients in the intramedullary rod group required allogeneic transfusion (*P* = .50). DVT occurred in 4 of 108 patients in the CAS group and 5 of 108 patients in the intramedullary rod group (*P* = .56).

Discussion

The most important finding of this study was that postoperative blood loss did not differ between patients who underwent TKA with or without the intramedullary reaming procedure.

There are various reports on the impact of intramedullary reaming on bleeding, with inconsistent results. Rathod et al. compared patients that underwent distal femoral osteotomy using an intramedullary rod during TKA (n = 14) with those who underwent distal femoral osteotomy without intramedullary reaming using CAS (n = 15) [10]. They reported no statistically significant difference in postoperative hemoglobin levels between the 2 groups. Singla et al. randomized patients undergoing TKA into a group that underwent femoral osteotomy using imageless navigation (n = 29) and a group that underwent femoral osteotomy using an intramedullary rod (n = 28) to compare total blood loss [11]. They reported no difference in total blood loss between the 2 groups. While some reports suggest that the presence or absence of femoral intramedullary reaming has no effect on blood loss, others indicate that avoiding intramedullary reaming reduces blood loss. Merz et al. reported that in patients who underwent simultaneous bilateral TKA, those who avoided intramedullary reaming using a navigation system (n = 62) had significantly higher hemoglobin levels on postoperative days 1 and 2 than those who used an

Table 2
Patient demographic and baseline clinical characteristics after propensity score matching.

Characteristic	Intramedullary rod group (n = 118)	Computer-assisted-surgery group (n = 118)	*P*-value	Standardized mean difference
Age, years	75 ± 7	74 ± 8	.69[a]	0.052
Sex (female/male)	100/18	101/17	>.99[b]	0.024
Height, cm	152 ± 8	152 ± 7	.62[a]	0.064
Weight, kg	63 ± 11	63 ± 12	.94[a]	0.010
Body mass index, kg/m^2	27.1 ± 4.3	27.2 ± 4.3	.90[a]	0.016
Preoperative hemoglobin level, g/dL	13.1 ± 1.3	13.1 ± 1.3	.81[a]	0.031

Results are expressed as means ± standard deviation, unless otherwise indicated.
[a] *P*-values were determined with Student's *t* test.
[b] *P*-values were determined with chi-squared test.

Table 3
Perioperative total blood loss calculated from blood volume and change in hemoglobin before matching.

Duration after surgery	Intramedullary rod group (n = 220)	Computer-assisted-surgery group (n = 129)	95% CI	*P*-value
Postoperative day 1, mL	373 ± 195	348 ± 209	−19 to 69	.27[a]
Postoperative day 3, mL	586 ± 271	522 ± 281	3-125	.039[a]
Postoperative day 7, mL	654 ± 258	599 ± 257	−2 to 112	.058[a]

Results are expressed as means ± standard deviation.
[a] *P*-values were determined with Student's *t* test.

intramedullary rod (n = 62) [8]. In addition, Ikawa et al. conducted an RCT comparing the accuracy of femoral coronal osteotomy in patients who underwent distal femoral osteotomy using a portable navigation system (n = 121) vs those who underwent distal femoral osteotomy using an intramedullary rod (n = 120) [9]. Although the primary outcome of that study was femoral coronal osteotomy accuracy, they also evaluated postoperative blood loss as a secondary outcome and found that the group using the portable navigation system had less blood loss. These previous studies, however, had limitations such as small sample sizes [10,11], lack of adjustment for preoperative factors [8,10], or only examined postoperative bleeding as a secondary outcome in an RCT [9]. In contrast, our study adjusted for factors affecting postoperative bleeding using propensity scores, reducing the potential influence of confounding factors compared to previous studies on similar topics.

The intramedullary rod hole was routinely sealed with an autologous bone graft in the intramedullary rod group. Closing the medullary canal may reduce blood flow from bleeding vessels into the joint cavity [15,16]. This plugging technique may have influenced the results of our study.

Regarding the clinical relevance of this study, there is no need to intentionally avoid intramedullary reaming in TKA to reduce postoperative blood loss. Patients with older age, preoperative anemia, low body mass index, and an American Society of Anesthesiologists physical status class of >2 have been shown to be at higher risk of allogeneic blood transfusion [1]. Even for such high-risk patients, this study supports the use of familiar methods, including conventional intramedullary rods, without requiring specialized equipment.

A limitation of this study is that it is retrospective. However, factors affecting postoperative blood loss were adjusted using propensity scores, suggesting that the impact of confounding factors may be smaller than that reported in previous studies. In addition, since all surgeries were performed or supervised by a single surgeon, the generalizability of this study may be limited. Nevertheless, the fact that all surgeries were performed by the same surgeon minimizes the influence of variations in surgical techniques on blood loss.

Table 4
Perioperative total blood loss calculated from blood volume and change in hemoglobin after propensity score matching.

Duration after surgery	Intramedullary rod group (n = 118)	Computer-assisted-surgery group (n = 118)	95% CI	*P*-value
Postoperative day 1, mL	379 ± 177	347 ± 211	−24 to 79	.21[a]
Postoperative day 3, mL	588 ± 249	529 ± 277	−17 to 121	.092[a]
Postoperative day 7, mL	664 ± 254	600 ± 262	−1 to 135	.060[a]

Results are expressed as means ± standard deviation, unless otherwise indicated.
[a] *P*-values were determined with Student's *t* test.

Conclusions

The postoperative total blood loss in TKA without the use of a femoral intramedullary alignment system did not significantly differ from that in TKA using a femoral intramedullary rod.

Conflicts of interest

S. Tsukada has not received any royalties during the study period but is scheduled to receive royalties from Zimmer Biomet Japan. S. Tsukada certifies receipt of personal payments during the study period, in an amount of less than USD 10,000 from Zimmer Biomet Japan and Stryker Japan; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2025.101647.

CRediT authorship contribution statement

Sachiyuki Tsukada: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Hiroyuki Ogawa:** Writing – original draft. **Masayoshi Saito:** Writing – original draft. **Masahiro Nishino:** Writing – original draft. **Takuya Kusakabe:** Writing – original draft. **Naoyuki Hirasawa:** Writing – original draft.

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