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KNEE ARTHROPLASTY

# Bleeding in TKA: posterior stabilized vs. cruciate retaining

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**Abstract**
*Introduction* Posterior-stabilized (PS) and cruciate-retaining (CR) total knee arthroplasties (TKA) are both successfully used for treatment of end-stage osteoarthritis. The choice of constraint depends on knee deformity and stability as well as most importantly surgeon preference. The aim of this study was to compare the amount of blood loss and required transfusions following TKA with the two different designs.
*Materials and methods* In a retrospective approach, 473 patients undergoing TKA were included (240 CR and 233 PS from a single manufacturer). Demographics at base line were comparable between both groups. Blood loss [red blood cell (RBC) loss] was calculated after documentation of pre- and postoperative hematocrit levels at discharge. Transfusion requirements were recorded. Statistical analysis was done using Mann–Whitney *U* test.
*Results* The calculated blood loss (RBC loss) at discharge was $548 \pm 216$ ml in the PS group compared with $502 \pm 186$ ml in the CR group ($p = 0.032$). There were no differences in the transfusion requirements between both groups (PS 0.41 vs. CR 0.37, $p = 0.39$).
*Discussion* The blood loss was significantly higher in the PS group. This may be due to the box preparation that exposes more cancellous femoral bone, which may add to postoperative bleeding. The differences remain, however, small, as they did not lead to a significantly higher transfusion rate with PS TKA.

**Keywords** Total knee arthroplasty · Blood loss · Posterior stabilized · Cruciate retaining

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## Introduction

Total knee arthroplasty (TKA) occupies a central position in the treatment of end-stage gonarthrosis, if previously taken conservative and joint-preserving surgical measures do not lead to adequate therapeutic success. However, primary TKA often leads to an increased blood loss in a clinically relevant range [1–4]. Frequently, blood transfusions are necessary [3, 5–10]. Following TKA, indications and incidence of transfusions differ largely between studies and institutions and may lead to transfusions in as much as 30 % of the men and 48 % of the women [11].

Both, blood loss and transfusion of blood can jeopardize patient health via cardiovascular incidents, infection or allergic reactions [12] and add to significant costs to the health care system [13]. The reduction of perioperative blood loss and the reduction of transfusion requirements in primary TKA should be a clinical priority.

Some potential factors for increased blood loss and transfusion requirements have been reported. A low preoperative hemoglobin concentration, the operation duration or gender were identified as factors [12, 14]. Some authors state that perioperative blood loss mainly originates from bone cuts uncovered by cement and implants [14–16]. Most of these factors cannot be influenced preoperatively.

Different levels of constraint are applied in TKA. Both, cruciate-retaining (CR) and posterior-stabilized (PS) TKA are successfully used in the treatment of severe knee

osteoarthritis. The choice of the implant constraint depends on factors such as the deformity of the knee, its stability, but also mainly on surgeon preference.

The aim of this study is to investigate the factor "primary TKA constraint" in terms of blood loss and the need for transfusion. It was hypothesized that patients following implantation of a PS TKA would suffer higher blood loss and require more blood transfusions than patients undergoing CR TKA.

## Patients and methods

In a retrospective study, 473 patients who received a primary-cemented CR or PS TKA (Genesis II, Smith & Nephew, Memphis, TN, USA) for osteoarthritis at the authors' institution between July 2005 and March 2009 were included. Anemic patients with low preoperative hemoglobin concentration (female <11.7 g/dl, male <13.3 g/dl) were preliminarily excluded to rule out bias as these patients are considered to reach critical transfusion levels easier. The study had IRB approval and adheres to the principles stated in the revised version of the Declaration of Helsinki.

A chart review was performed and demographic data as well as the TKA design were documented (Genesis II PS or CR). In addition, the preoperative and discharge hemoglobin concentration and hematocrit as well as the need for and amount of blood transfusions were recorded. The mean length of stay was 14.7 ± 3.13 days. In addition to the chart review, a screening of the electronic patient file (Orbis, Agfa Healthcare, Bonn, Germany) and the database of the institution's blood bank was performed.

TKA was performed with tourniquet via a medial parapatellar approach under general anesthesia or spinal anesthesia and in some patients an additional femoral nerve block following the manufacturer's instructions. The tourniquet was inflated prior to incision and released before wound closure. Bleeders were cauterized. An intra-articular and a subcutaneous drain were inserted and removed on the second postoperative day. Capsule and subcutaneous tissue were closed meticulously in layers and the skin was closed with staples. A compressive bandage was applied and left in place until the second postoperative day.

Enoxaparin (Clexane 40 mg, Sanofi-Aventis, Frankfurt, Germany) was used for deep venous thrombosis prophylaxis for 6 weeks post-op giving the first dose the night before surgery. Controlled passive motion device, physical therapy, and mobilization were started the first postoperative day.

A common trigger point for transfusions was determined as a hemoglobin level <8 g/dl unless medical reasons necessitated a transfusion above that level. All transfusions were allogeneic.

Blood loss was calculated as described by Charrois et al. [17]: Total blood loss (ml of erythrocytes: 100 % hematocrit) = compensated blood loss + non-compensated blood loss; compensated blood loss (ml) = number red blood cell units × ml red blood cells (RBC) per red blood cell unit (170 ml per unit); non-compensated blood loss (ml): = total blood volume × (preoperative hematocrit − postoperative hematocrit); total blood volume (ml): in men = 604 + 0.0003668 × [height (cm)]$^3$ + 32.2 × weight (kg); in women = 183 + 0.000356 × [height (cm)]$^3$ + 33 × weight (kg).

The statistical analysis was performed using SPSS (Version 18.0, SPSS, Chicago, IL, USA) and Microsoft Office Excel 2010 (Microsoft Corporation, Seattle, USA). Since we could not assume a normal distribution of the target parameters based on the results of the Kolmogorov–Smirnov tests, the nonparametric $U$ test of Mann and Whitney was applied. A $p$ value of <0.05 was considered significant.

A post hoc power analysis was performed using the following parameters: 80 % power, a critical $p$ value of 0.05. A sample size of 435 subjects was calculated to detect a difference in RBC loss of 27 ml.

## Results

In this retrospective approach, 473 patients undergoing TKA were included (240 CR and 233 PS). Demographics at base line were comparable between both groups (Table 1).

The calculated blood loss (RBC loss) at discharge was 548 ± 216 ml in the PS group compared with 502 ± 186 ml in the CR group, which was significantly different ($p = 0.032$).

There were no differences in the transfusion requirements between both groups (PS 0.41 vs. CR 0.37, $p = 0.39$).

**Table 1** PS vs. CR Demographics at base line, blood loss and transfusion requirements

| Variable | PS ($n = 233$) | | CR ($n = 240$) | | $p$ value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Age (y) | 66.8 | 9.2 | 67.1 | 10.4 | 0.34 |
| Sex (F/M) | 152/81 | 0.48 | 162/78 | 0.47 | 0.60 |
| BMI (kg/m$^2$) | 31.4 | 5.98 | 30.3 | 4.92 | 0.18 |
| Weight (kg) | 88.4 | 18 | 85.0 | 16 | 0.06 |
| Height (cm) | 167.8 | 8.82 | 167.4 | 8.44 | 0.66 |
| Operation time (min) | 87.2 | 24.2 | 83.7 | 19.7 | 0.24 |
| RBC loss (ml) | 547.7 | 215.7 | 501.5 | 186.5 | 0.03* |
| Transfusions ($n$) | 0.41 | 0.92 | 0.37 | 0.92 | 0.39 |

## Discussion

The hypothesis that patients following implantation of a PS TKA would suffer higher blood loss than patients undergoing CR TKA was proven correct. However, absolute differences (mean 46 ml) remain small and are clinically most likely irrelevant as this did not lead to differences in requirement of blood transfusions between groups.

The results of our study can possibly be explained by the additional preparation of the femoral box PS TKA for the cam-post mechanism. More femoral cancellous bone surface will be exposed contributing to increased perioperative bleeding [14–16]. Due to the retrospective nature of this study, differences in indications and preoperative deformity cannot completely ruled out as possible confounders for perioperative bleeding and consecutive transfusion requirements.

To the best of our knowledge there are only two studies comparing blood loss between PS and CR TKA. Our results are in concordance with a recent prospectively randomized trial reported by Canyaka et al. [18], who also found increased blood loss with the PS design of 74 ml, using Vanguard, Biomet, Warsaw, IN, USA. It may be speculated that due to the sample size of 100 patients this difference did not reach statistical significance. They also found no differences in terms of transfusion requirements.

Scott et al. [19] compared cruciate substituting (CS) with PS TKA (Triathlon, Stryker, Mahwah, NJ, USA). CS TKA aims to substitute function of the posterior cruciate ligament via a more congruent implant that does not require preparation of a box for the cam-post mechanism. Exposure of cancellous bone with the CS design thus should correspond largely with that of the CR design used in our study. Including 111 patients, equivalent pre- and postoperative hemoglobin levels for both groups were found while there were significantly more transfusions required in the PS group ($p < 0.039$). However, in their study total blood loss was not calculated.

In the literature, some explanations for the perioperative blood loss following TKA surgery exist mainly due to trauma to the bone and soft tissues. Perioperative blood loss from the venous sinus of the trimmed bone is referred to as the main source of bleeding. In addition, the fibrinolysis system is enhanced through osteotomies as required for TKA implantation. In addition, the use of a tourniquet leads to secondary hyperemia with increased activity of the fibrinolytic system [6, 20–24]. An additional effect on postoperative blood loss may be added through the use of suction drains, preventing compression of the soft tissues via postoperative hematoma [25, 26].

Measuring perioperative blood loss in TKA is controversially discussed. Blood loss as determined by measuring intraoperative bleeding volume through weight gain of sponges and content of suction containers and postoperative drainage is subject to several confounders. The intraoperative use of irrigation fluid may affect fluid volume in suction containers and hemoglobin concentration of drained fluids will differ from the actual patient hemoglobin concentration. Hidden blood loss caused by bleeding into the soft tissues and the joint cavity as well as hemolysis has to be taken into account as it significantly contributes to the overall blood loss [3, 7]. Pure measuring of the visible drainage and intraoperative bleeding will significantly underestimate blood loss.

In the present trial perioperative blood loss was calculated based on the pre- and postoperative hematocrit taking into account patients' height, body weight, sex, and the volume of transfusions as proposed by Charrois et al. [17]. There is consensus that this indirect calculation of blood loss seems to be the most precise and most widely used method to determine blood loss as it is less sensitive to changes in hydration status or fluid management, e.g., the hemoglobin concentration. Our calculations represent a close approximation of the actual blood loss [27–29].

### Limitations and strengths of the study

The most obvious limitation to this study arises from its retrospective design as mentioned above. Results may also slightly differ between manufacturers, surgeons and the operative technique. A major strength results from the rather high number of cases of 473 patients who were included into this study adding to its high power to detect minor differences in blood loss between the two studied groups.

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