



Cemented and hybrid total hip arthroplasty lead to lower blood loss in primary total hip arthroplasty: a retrospective study

Nils Meißner¹ · Andreas M. Halder¹ · Daniel Schrednitzki¹

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Abstract

Background Little scientific evidence exists on blood loss and transfusion rates depending on the fixation technique. The hypothesis of this study was that the blood loss and transfusion rate are lower in cemented and hybrid total hip arthroplasty (THA) compared to cementless THA.

Methods We retrospectively compared a total of 1500 patients who received either cementless, cemented, hybrid or reverse hybrid THA. All patients underwent THA in 2021 at a single orthopedic center in Germany.

Results The lowest blood loss was found in patients who received a fully cemented THA (695 ± 74 ml). Hybrid THA with a cemented stem showed a blood loss of 845 ± 30 ml and reverse hybrid THA showed the highest blood loss with an average of 994 ± 74 ml. Cementless THA caused an average blood loss of 957 ± 16 ml. There was a significant difference between cementless THA, hybrid THA (cemented stem), and fully cemented THA ($p < 0.05$). Transfusion rates ranged from 1.3% (cementless THA) to 7.9% (cemented THA) between the groups with a transfusion rate of 2.5% overall.

Conclusion We found significantly lower blood loss in cemented THA and hybrid THA compared to cementless THA. Although blood loss was lower in cemented and hybrid THA, this did not result in lower transfusion rates. This could be due to other confounders such as age, comorbidities, and preoperative anemia.

Keywords Total hip arthroplasty · Cemented · Cementless · Hybrid THA · Blood loss · Patient blood management

Introduction

Total hip arthroplasty (THA) is one of the most successful orthopedic surgeries of the past century with good to excellent long-term results [1]. In Germany in 2020, 95.9% of all THA performed were primary [2].

In other European countries, such as Sweden, cemented fixation is the most common fixation technique because of poor results of cementless fixation during the 1990s. However, in recent years with improved implants, cementless fixation was regaining popularity. In 2019, the cementless implantation technique was used in 27.8% of all THAs in Sweden [3].

In contrast to that, the majority of THA are implanted in a cementless press-fit technique in Germany. In 2020, the German Arthroplasty Registry (EPRD) showed that 77.6%

of all THAs were implanted without cement [2]. Cemented fixation of the femoral component (Hybrid THA) is more common in elderly patients. In Germany, the mean age of patients who underwent cementless primary THA was 67 years in 2020. For hybrid THA, it was 79 years, and for cemented fixation, it was 81 years [2].

The estimated blood loss after THA is reported to be between 900 and 1500 ml [4, 5]. Studies report transfusion rates of up to 69% [6], but with new surgical approaches and the implementation of patient blood management protocols, this has been reduced to about 10% in recent years [7].

High blood loss could result in anemia and the need for allogeneic blood transfusions (ABT). ABT are also associated with risks, such as pathogen transmission, immunomodulation, or transfusion-related lung injury (TRALI) [8, 9]. In addition, anemia is associated with increased morbidity and even mortality [10, 11]. Blood-saving measures, such as the use of tranexamic acid, led to a reduction in blood loss [12–15]. Other possibilities should be assessed to further reduce blood loss. Therefore, patient blood management (PBM) gained more interest and improved patient

✉ Nils Meißner
Nils.Meissner@sana.de

¹ Department of Orthopaedic Surgery, Sana Kliniken Sommerfeld, Waldhausstr. 44, 16766 Kremmen, Germany

outcomes [16]. PBM includes preoperative optimization of hemoglobin levels (Hb), standardized transfusion protocols, and blood-sparing techniques [16].

This study investigates whether blood loss depends on the THA fixation technique and, if so, whether blood loss is lower in hybrid or cemented THA compared to cementless

guidelines. Preoperatively, hemoglobin concentration (Hb) and hematocrit values (Hk) were routinely obtained 1 day before surgery. Postoperatively, Hb and Hk were routinely obtained on the first and third post-operative days. Blood loss was calculated using the Hb balance method [17] and blood volume using Nadler's formula [18]:

$$\text{Blood loss (ml)} = \text{Blood volume (ml)} \times \frac{\text{Hb preOP} \left(\frac{\text{g}}{\text{dl}} \right) - \text{Hb postOP} \left(\frac{\text{g}}{\text{dl}} \right)}{\text{Hb preOP} \left(\frac{\text{g}}{\text{dl}} \right)} + \text{blood transfused (ml)}$$

THA. We hypothesized that blood loss is lower in cemented and hybrid THA than in cementless THA.

Blood volume was assumed using the formula of Nadler et al.

$$\text{Blood volume (ml)} = (k1 \times \text{height (m)}) + k2 \times \text{weight (kg)} + k3$$

Materials and methods

Retrospectively 1500 consecutive patients who underwent primary THA in 2021 in a single German orthopedic center were reviewed. All patients were included in this study. One thousand one hundred and twenty-nine of these patients received cementless THA (group 1), thirty-eight patients cemented (group 2), and three hundred and thirty-three received hybrid (two hundred and ninety-four; group 3) or reverse hybrid THA (thirty-nine; group 4). For all patients, the same minimally invasive anterolateral approach was used. In all patients, the same PMMA cement was used if applicable (Palacos®, Heraeus Medical GmbH, Wehrheim, Germany). Cemented fixation was used in patients over 80 years of age, if clinically evident osteoporosis was present or if primary implant stability was not achieved using the press-fit technique. All patients were preoperatively evaluated in terms of anemia and in the case of iron deficiency substituted (1 g Ferinject® i.v., Vifor Pharma Deutschland GmbH, München, Germany). All patients were warmed pre-, peri- and post-operatively with an active heating system and warmed i.v. fluids according to the hospital standard.

Blood-saving measures included use of tranexamic acid if no contraindications were present (preoperative: orally 1 g or 1.5 g if > 100 kg body weight, 1 g topical and 500 mg 1–1–1 orally post-operatively for 2 days). No drains were used. If necessary, anti-plated therapy was continued, according to individual risk management. All patients received NSAID with selective COX-2 blockers as pain medication if no terminal kidney disease or other contraindications were present. No patients with terminal kidney disease were treated in our institution, due to a lack of dialysis resources. Low-molecular-weight heparin (LMWH, 40 mg once daily) was used as a thromboembolic prophylaxis according to the German

with $k1 = 0,3669$, $k2 = 0,03,219$, $k3 = 0,6041$ for men and $k1 = 0,3561$, $k2 = 0,03,308$, $k3 = 0,1833$ for women.

All blood transfusions were recorded. The indication for blood transfusion was Hb < 4.8 g/dl and cardiovascular symptoms with hypotension and tachycardia. All data for this study were obtained from the institutional database. Furthermore, complication statistics were reviewed in regard to major bleeding events such as gastrointestinal bleedings and ulceration.

Statistical methods

Statistical analysis was performed with SPSS® (Version 27). A nonrepeated ANOVA was used to compare blood loss between the groups. Furthermore, Bonferroni and two-sided paired Student's *t* tests were used to compare blood loss between the different groups. *p* values < 0.05 were considered significant. All values are presented as means with standard error of mean or mean with range (age, body mass index).

Results

The mean age of all patients was 68.7 years (20–93 years), mean body mass index (BMI) was 28.9 kg/m² (17.7–50.6 kg/m²).

Group 1 was the largest group with 1129 patients who received cementless THA (75.2%). The smallest group was group 2 with only 38 patients (2.5%) with fully cemented THA. With 294 patients, the second largest group accounted for group 3 who received a hybrid THA, and 39 patients in group 4 received a reverse hybrid THA.

The groups were significantly different in ASA, BMI, and age. Post hoc analysis with Bonferroni tests showed significant differences between group 1 compared to group 2 and 3. The patients in groups 2 and 3 were older ($p < 0.001$), weighed less (BMI, $p < 0.001$), and were sicker (ASA, $p < 0.05$) than the patients in group 1 (Table 1).

The calculated blood loss in group 1 (cementless THA) was 957 ± 16 ml. Blood loss in group 2 (cemented THA) was lowest at 695 ± 74 ml and in group 3 (hybrid THA) 845 ± 30 ml. Group 4 had the highest calculated blood loss with 994 ± 74 ml (Table 2, Fig. 1).

The ANOVA analysis showed significant differences in the calculated blood loss between the groups ($p < 0.005$). Post hoc analysis with Bonferroni testing showed that blood loss between reverse hybrids was not significantly different from blood loss in cementless THA ($p = 1.0$). Group 2 ($p = 0.012$) and group 3 ($p = 0.021$) had significantly lower blood loss compared to group 1. The difference in calculated blood loss between groups 2 and 3 was not significant ($p = 0.087$) (Table 3). A total of 37

Table 3 p values for calculated blood loss comparison between all groups using Bonferroni post hoc analysis

	Group 1	Group 2	Group 3	Group 4
Group 1		0.012*	0.021	1.000
Group 2	0.012		0.601	0.087
Group 3	0.021*	0.601		0.647
Group 4	1.000	0.087	0.647	

Significant p values are marked with*

of the 1500 patients received a blood transfusion (2.5%). Of these, 15 received a cementless THA (transfusion rate 1.3%). Nineteen patients with partially cemented THA received a transfusion, seventeen with hybrid THA (transfusion rate 5.8%), and two with reverse hybrid THA (transfusion rate 5.1%). The highest transfusion rate was found in patients who received cemented THA (3/39 patients, transfusion rate 7.9%). No major bleeding events occurred during the study period.

Table 1 Descriptive data for all patients ($n = 1500$), who received primary THA

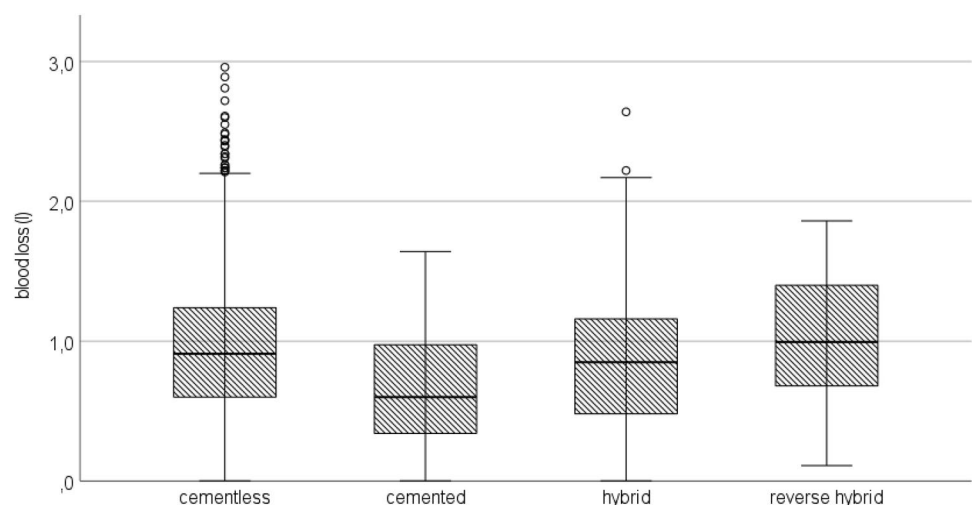
	Group 1 cementless	Group 2 cemented	Group 3 hybrid	Group 4 reverse hybrid
n	1129	38	294	39
BMI kg/m^2	29.2 ± 0.16	24.8 ± 0.86	27.2 ± 0.25	27.7 ± 0.70
Age (years)	65.6 ± 0.25	81.0 ± 1.38	79.6 ± 0.38	63.7 ± 1.19
ASA	2.1 ± 0.01	2.32 ± 0.05	2.28 ± 0.03	2.05 ± 0.08

All values are presented as means with standard error of mean

Table 2 Pre- and post-operative Hb levels, calculated blood loss and Transfusion rates

	Group 1 cementless	Group 2 cemented	Group 3 hybrid	Group 4 reverse hybrid
PreOP Hb mmol/l	8.15 ± 0.03	7.24 ± 0.13	7.68 ± 0.06	7.91 ± 0.13
Postop Hb mmol/l	6.84 ± 0.02	6.28 ± 0.13	6.49 ± 0.04	6.44 ± 0.13
Blood loss ml	957 ± 16	695 ± 74	845 ± 30	994 ± 74
Transfusion rate	1.3%	7.9%	5.8%	5.1%

Fig. 1 Calculated blood loss in comparison between cementless, cemented, hybrid, and reverse hybrid THA



Discussion

This study investigated the calculated blood loss and transfusion rates in THA using different fixation techniques. Blood loss was significantly lower in cemented THA and hybrid THA compared to cementless THA ($p < 0.05$). The overall transfusion rate was 2.5%.

Many studies have reported in the past that THA leads to substantial blood loss [18, 19]. This often requires ABT [6, 18, 19]. The demographic change in western societies leads to a growing number of elderly patients [20]. Consequently, until the COVID-19 pandemic, the numbers of THA performed per year were constantly increasing [2, 20] and projections show an increase of 27% from 2010 to 2040 [20]. Hence, a higher absolute demand for allogeneic blood is expected.

As blood transfusion is common in THA, individual health risks associated with ABT should be considered. In general, ABT is associated with increased morbidity, mortality, and costs [10, 11]. To improve the patient's outcome and lower complication rates, PBM is a key factor in elective THA. Minimizing blood loss and thus minimizing transfusion is crucial in THA.

The transfusion rate in this study was 2.5% on average, ranging from 1.3% to 7.9%. Higher transfusion rates in patients receiving a hybrid or fully cemented THA, while losing less blood might be explainable due to preoperative lower Hb values (Table 2). Studies have shown in the past that preoperative low Hb values can result in higher transfusion rates [21]. Compared to previous reports with transfusion rates of up to 69% [6, 18, 19], the transfusion rate in this study was low. Hochreiter et al. described transfusion rates between 8% and 15.8% comparing 124 patients in 2 groups using an anterolateral approach with cementless short-stem or straight-stem design with calculated blood loss between 1139 and 1358 ml, respectively [18]. Compared to our findings, the calculated blood loss was higher. Due to the different sample sizes and the different equations used to determine the actual blood loss, assessing blood loss and comparability between studies is difficult [22]. Wong et al. found transfusion rates of 23% in their prospective observational study of 787 patients [23]. Demey et al. evaluated the influence of femoral cementing in their study of 130 patients who underwent total knee arthroplasty (TKA) and found no difference between the groups [24]. To our knowledge, there are no comparative studies evaluating the influence of cementing in THA.

A considerable limitation of this study is the retrospective design and differences in group sizes. Although the total number of patients included in this study is quite large, the group size ranges from 38 to 1129 patients. Additionally, an individual indication for blood transfusion cannot be ruled out. Although there is a threshold for transfusion with an Hb

level of 4.8 g/dl and lower, clinical symptoms could influence the decision to transfusion in patients with higher Hb levels.

Furthermore, not all factors could be assessed in this study. With regard to possible other confounding medication, such as anti-plated therapy or usage of NSAID, the literature reports no effect of such medication on blood loss in primary arthroplasty [25–27]. Chronic kidney disease (CDK) was not assessed in this study as a possible confounder. Though, recent studies showed no negative effects on transfusion rates in an adjusted PBM protocol for patients [28]. There were no major bleeding events found in our complication records for the study period, so a possible influence on transfusion rate can be ruled out.

Conclusion

Although other confounders might influence transfusion rates and blood loss, such as BMI, comorbidities, preoperative Hb levels, use of tranexamic acid and approach, this study shows the effect of PMMA bone cement for femoral fixation on blood loss in THA. Therefore, femoral stem cementing should be considered in the elderly patient with comorbidities to minimize blood loss.

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Data availability The datasets generated during and/or analyzed during the current study are available from corresponding author on reasonable request.

Declarations

Conflict of interest Prof. Andreas Halder and Dr. Daniel Schrednitzki declare royalties from ZimmerBiomet and Depuy. They declare paid presentations for ZimmerBiomet and Depuy. Mr. N. Meißner declares no conflict of interest related to the present study.

Ethical approval No IRB approval was necessary for this study, as this study presents the collection, analysis, and publication of retrospectively obtained and anonymized data. No sensible data were presented in this study.

Informed consent All patients signed an informed consent for the surgical procedure.

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