



One-stage bilateral versus unilateral short-stem total hip arthroplasty: A matched-pair analysis of 216 hips

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ABSTRACT

Background: One-stage, bilateral, short-stem total hip arthroplasty (1B-ssTHA) represents an alternative to staged, unilateral, short-stem total hip arthroplasty (U-ssTHA); however, the safety and reliability of 1B-ssTHA remain unknown. The objective of the present study was to compare the functional outcomes, complications, and mortality rates between 1B-ssTHA and U-ssTHA at mid-term.

Methods: A retrospective, matched-pair study was performed, including 216 short stems implanted in 162 patients. Among the study population, 54 patients were treated with 1B-ssTHA. Patients were matched by gender, age, body mass index (BMI), and American Society of Anesthesiologists (ASA) classification. A total of 46 full matches could be accomplished. The mean follow-up time for the 1B-ssTHA group was 61.7 months (standard deviation [SD] 6.2 months), compared with was 63.4 months (SD 8.0 months) for the U-ssTHA group. Mortality, complication, and revision rates were documented. For clinical examinations, the visual analogue scale (VAS) was used to evaluate satisfaction, rest pain, and load pain, and the Harris Hip Score (HHS) was determined.

Results: No surgery-related deaths were observed. At mid-term, none of the 1B-ssTHA patients required stem revision. The rate of complications for both groups was low. The mean drop in haemoglobin measured in the 1B-ssTHA group was 4.42 mg/dl, compared with 3.18 mg/dl in the U-ssTHA group. The mean HHS in the 1B-ssTHA group was 98.3 points (SD 2.80), whereas, in the U-ssTHA group, the mean HHS was 97.9 points (SD 3.44) ($p = 0.478$). Satisfaction rates were significantly higher in the 1B-ssTHA group ($p = 0.04$) than in the U-ssTHA group, whereas no significant differences were found for pain at rest and pain at load ($p = 0.56$ and $p = 0.26$, respectively).

Conclusion: Our findings indicate that 1B-ssTHA is an effective and beneficial procedure for a select population. Mortality, complications, implant survival, and clinical outcomes were comparable to those for a matched group with unilateral osteoarthritis treated with U-ssTHA. However, an increase in blood loss must be acknowledged for the 1B-ssTHA procedure.

1. Introduction

One-stage, bilateral, short-stem THA (1B-ssTHA) represents an alternative to staged, unilateral, short-stem THA (U-ssTHA). However, the safety and reliability of 1B-ssTHA remain unknown. One-stage, bilateral THA (1B-THA) is a common and well-assessed procedure performed in North America^{1,2} but is rarely used in Europe, with little data available.^{3,4}

Although some authors have reported an increased complication risk associated with 1B-THA,^{5–7} others have found no additional risk compared with staged THA.^{1,8} A slightly higher implant revision risk was identified in the Swedish hip arthroplasty register for 1B-THA patients compared with unilateral THA patients.⁹ Most authors agree that proper patient selection is necessary for 1B-THA, especially patients with low American Society of Anesthesiologists (ASA) scores (Grades I and II).^{10,11}

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To ensure procedural safety, short operation time, low blood loss, and distinct muscle-sparing techniques should be pursued when performing 1B-THA.¹² In addition to the use of minimally invasive surgeries (MIS) that reduce soft-tissue damage, contemporary short stems have become increasingly popular.^{12,13} Short stems represent an alternative to conventional stems, preserving bone and soft-tissue, and favourable functional outcomes for short stems have been observed at mid-term stages.^{12–14} Operation times and blood loss may be reduced to low levels.^{12,14} However, long-term results for short stems remain scarce.

To date, very little data is available on 1B-THA using short stems.^{12,14}

The present study performed a comparison of 1B-ssTHA and U-ssTHA to analyse (1) mortality, (2) implant survival, (3) complication rates, and (4) clinical outcomes at mid-term follow-up. The hypothesis was that for a select population, 1B-ssTHA would show equivalent rates and comparable results for all four evaluated metrics compared with U-ssTHA.

2. Methods

This study was a retrospective single-centre matched-pair analysis. We identified 54 patients (Fig. 1) who underwent 1B-ssTHA between 2010 and 2012. For improved comparability, each patient was matched with a patient who experienced the same unilateral procedure during the same time period. Patients were matched by gender, age at the time of operation, body mass index (BMI), and ASA classification. If more than two controls were identified who matched all four parameters, we used the control with the date of birth closest to that of the case. A total of 46 complete matches were identified (Fig. 1).

All procedures were performed in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Freiburg Ethics Review Board (FEKI 010/2071), and all patients gave permission to participate in the study.

The inclusion criteria for 1B-ssTHA were bilateral osteoarthritis diagnosis and the absence of severe neurological and cardiovascular diseases. Patients older than 80 years were not considered for 1B-ssTHA. The indication in all cases was primary or secondary osteoarthritis.

The mean age of the 1B-ssTHA group was 63.4 years (range: 43.3–76.8 years), compared with was 63.1 years (range: 40.1–79.4 years) (Table 1) for the U-ssTHA group. The mean follow-up time for the 1B-ssTHA group was 61.7 months (standard deviation [SD]: 6.2 months), compared with 63.4 months (SD: 8.0 months) for the U-ssTHA group (Table 1).

The short stem optimys (Mathys Ltd., Bettlach, Switzerland) was implanted in all cases (Fig. 2). The optimys is a calcar-guided and bone-preserving prosthesis with multiple alignment possibilities. The short-stem philosophy relies on pronounced bone contact at the calcar and the distal lateral cortex. Thus, three-point anchoring is attempted, and in some cases, a fit and fill in the proximal diaphysis is possible.¹⁵ The short stems were combined with two different cementless cups [RM Pressfit vitamys (Mathys Ltd., Bettlach, Switzerland) or Fitmore cup (Zimmer, Warsaw, USA)] using a highly crosslinked polyethylene.

Table 1
Patient demographics.

	1B-ssTHA	U-ssTHA	p-value
Number of patients (n) (hips)	46 (92)	46 (46)	
Mean age at operation (years) (range)	63.4 (43.3–76.8)	63.1 (40.1–79.4)	0.76
Gender (n)	22 (47.8)	22 (47.8)	
Female	24 (52.2)	24 (52.2)	
Male			
Mean BMI (kg/m²) (SD)	27.5 (4.6)	27.8 (5.3)	0.48
Mean follow-up (years) (range)	61.7 (37.8–75.4)	63.4 (30.9–81.2)	0.23
Diagnosis (n) (%)	45 (97.8)	41 (89.1)	
Primary osteoarthritis	0 (0)	1 (2.2)	
Secondary osteoarthritis	1 (2.2)	4 (8.7)	
Necrosis			
ASA (n) (%)	1 (2.1)	1 (2.1)	
Grade 1	40 (87.0)	40 (87.0)	
Grade 2	5 (10.9)	5 (10.9)	
Grade 3			

All surgeries were performed using a minimally invasive antero-lateral approach with standardised surgical techniques.¹⁶ Postoperative, full-weight bearing was allowed.

During clinical examinations, the Harris Hip Score (HHS) was determined, and the visual analogue scale (VAS) was used to evaluate satisfaction, rest pain, and load pain.

2.1. Power analysis

To calculate the sample size, we used the HHS as the primary outcome (range: 0–100 points), with medium effect size, and a minimal clinically important difference (MCID) was determined to equal 10 points.¹⁷ The type I error (2-sided) equalled 0.05. Given a power of 80%, 36 patients were required for each group. To account for predicted loss to follow-up, we aimed to identify at least 40 matched patients for each group.

2.2. Statistical analysis

Statistical analysis was performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA). Descriptive statistics included the mean, SD, and range. Differences among matched patients were evaluated using paired t-tests, and Wilcoxon signed-rank tests were used for non-normal data. For bilateral patients, the mean values of the respective two pairings were used to this end. The level of significance was set at $p = 0.05$ (two-sided) for all tests.

3. Results

The present study included 46 matched pairs, corresponding to 92 patients and 138 hips (Fig. 1).

Three patients in the 1B-ssTHA group were deceased, with the

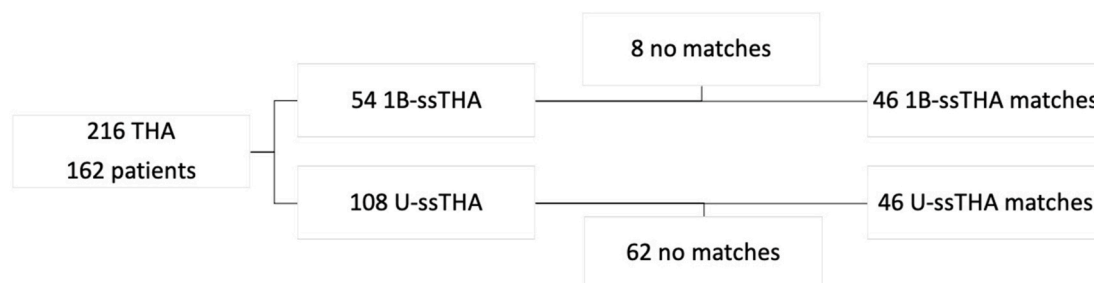


Fig. 1. Study flowchart of follow-up. (THA: Total hip arthroplasty; 1B-ssTHA: One-stage, bilateral, short-stem THA; U-ssTHA: Unilateral, short-stem THA).

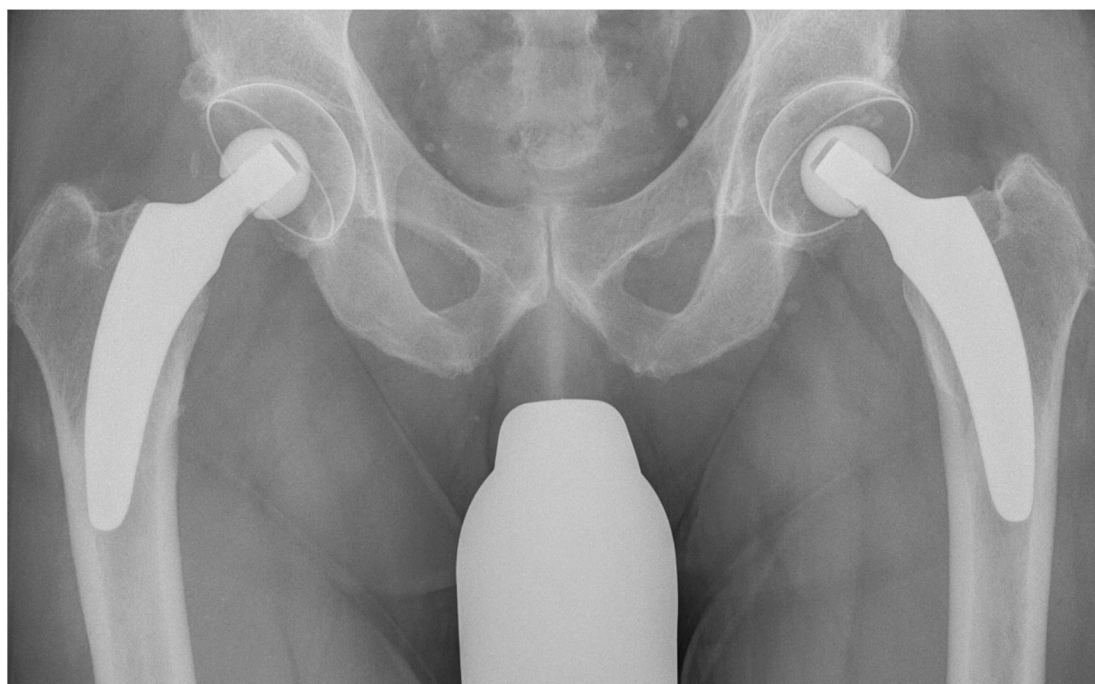


Fig. 2. Anteroposterior radiograph of one-stage, bilateral, short-stem total hip arthroplasty (optimys, Mathys Ltd. Bettlach, Switzerland).

investigated implants *in situ*. The causes of death in all three cases were unrelated to the surgical procedure and occurred beyond the first postoperative year. To date, no deaths have been reported in the U-ssTHA group.

The intraoperative and postoperative complications are documented in Table 2. In the 1B-ssTHA group, one patient experienced an intraoperative avulsion fracture of the greater trochanter on one side, without clinical dysfunction and requiring no therapy. One case of deep vein thrombosis (DVT) was reported, despite regular medical prophylaxis, which was treated successfully. A prolonged seroma was documented in one case on both sides. No periprosthetic infection occurred in the 1B-ssTHA group, and no patients required revision surgery. In the U-ssTHA group, one patient required revision due to an early, deep, periprosthetic infection; the patient received head and inlay changes without further consequences.

The mean haemoglobin drop was 4.42 mg/dl in the 1B-ssTHA group. Seven patients (13%) in the 1B-ssTHA group required at least one blood transfusion. In the U-ssTHA group, the mean haemoglobin drop was 3.18 mg/dl which was significantly less from that for the 1B-ssTHA group ($p \leq 0.001$), and no patients required blood transfusions. The postoperative day one haemoglobin values were 8.95 mg/dl (range: 6.10–11.80 mg/dl) in the 1B-ssTHA group and 10.59 mg/dl (range: 6.90–13.30 mg/dl) in the U-ssTHA group ($p \leq 0.001$; Fig. 3).

Before surgery, the HHS in the 1B-ssTHA group was rated at an average of 44.93 points (range: 18.00–78.50 points), whereas at mid-term, the mean HHS was 98.27 points (range: 90.00–100.00 points). In the U-ssTHA group, the mean HHS at baseline was 50.17 points (range: 13.00–88.00 points), whereas at mid-term, the mean HHS

increased to 97.91 points (range: 83.00–100.00 points). The mean difference in HHS between groups at the last follow-up was 0.50 points (range: –10.00–17.00), which was not significant ($p = 0.478$, Fig. 4).

The VAS-assessed pain and satisfaction scores are summarised in Table 3. A significant difference in satisfaction was observed between groups in favour of the 1B-ssTHA group ($p = 0.037$). In addition, the 1B-ssTHA group showed lower rest and load pain values, although these did not differ significantly from those in the U-ssTHA group (Table 3).

4. Discussion

The objective of this study was to compare the mid-term outcomes of 1B-ssTHA patients with those of U-ssTHA patients. The 1B-ssTHA procedure was not associated with a higher complication rate than the U-ssTHA procedure. To date, none of the 1B-ssTHA patients have required revision surgery. The clinical outcomes and patient satisfaction for both groups were comparable, with slightly better results for the 1B-ssTHA group. As expected, blood loss increased significantly during 1B-ssTHA.

On the one hand, 1B-THA may provide many obvious advantages, including limiting surgery, anaesthesia, hospitalisation, and rehabilitation to a single occurrence. On the other hand, the primary concern regarding 1B-THA is the complication rate. Numerous previous studies comparing 1B-THA with unilateral THA have reported an increased risk of complications associated with 1B-THA.^{2,5,7} For example, Berend et al.² compared 450 one-stage bilateral cases with 450 unilateral cases and found a higher pulmonary embolism rate in the bilateral group and a higher death rate, with seven deaths compared with three deaths in the unilateral group. However, this difference was not significant. Swanson et al.⁷ retrospectively analysed 400 1B-THA patients matched with 400 unilateral THA patients and observed an increased rate of minor complications in the bilateral group, such as electrolyte disturbance, urinary tract infection, and rash, and a trend toward increased major complication incidence, including myocardial infarction, pulmonary embolism, and fat embolism syndrome. No deaths were observed for either group. In an investigation of a nationwide inpatient sample from 2002 to 2010, including 2216257 THAs and 14798 1B-THAs, Rasouli et al.⁵ found a significantly increased risk of systemic but not local complications for 1B-THA compared with unilateral THA. However, no

Table 2

Complications.

Parameters	1B-ssTHA	U-ssTHA
Numer of patients (n) (hips)	46 (92)	46 (46)
Number of medical complications (n)	5	1
- DVT	1	0
- Haematoma/Seroma	2	0
- Fracture (greater trochanter)	1	0
- Periprosthetic Infection	0	1

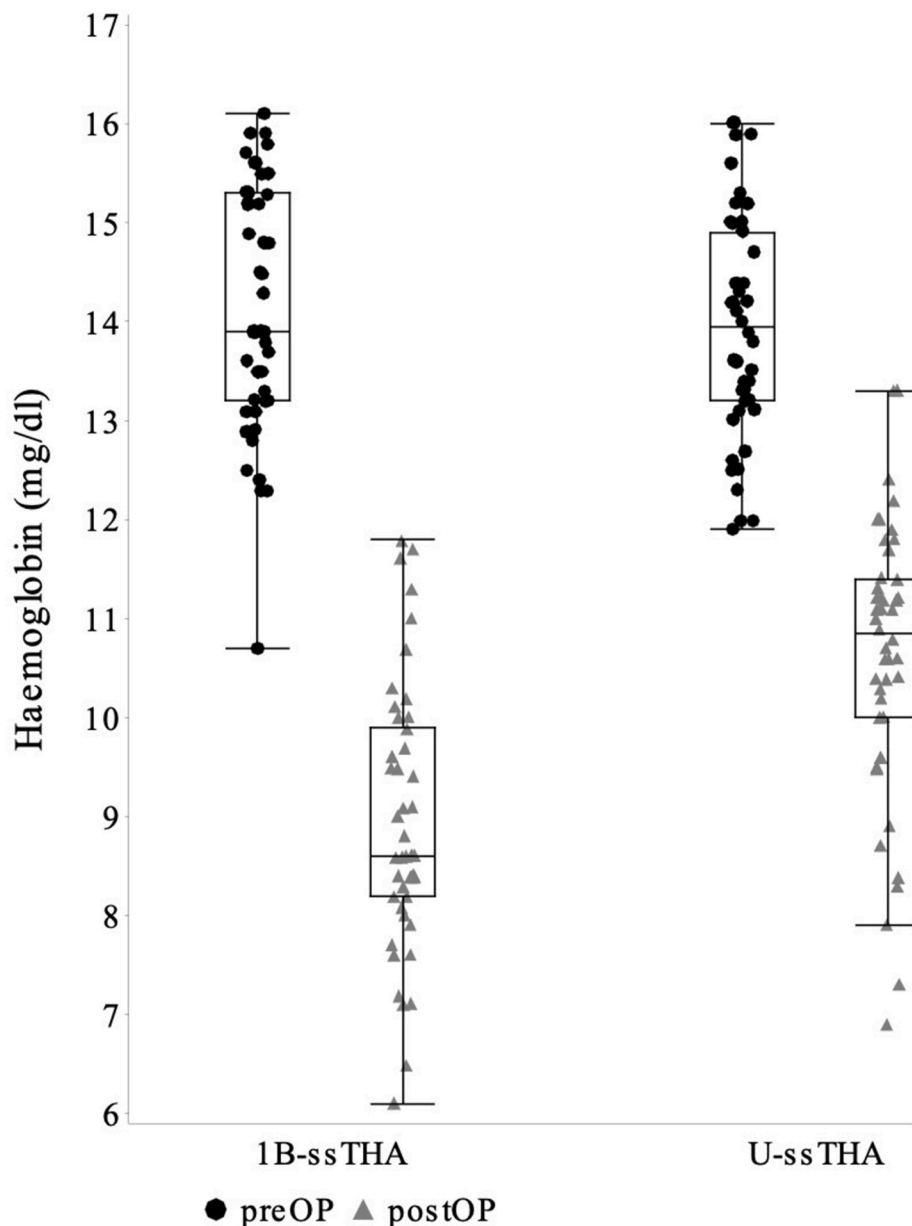


Fig. 3. Boxplot of haemoglobin values (mg/dl).

significant difference in risk was found between staged unilateral THA and 1B-THA.⁵

In contrast, some investigations did not detect any safety disadvantages for 1B-THA. Using data from a Canadian national database, a recent study found no differences in major complications or readmission rates for 1B-THA versus unilateral THA.¹⁸ Additionally, 1B-THA did not increase the 90-day mortality rate compared with unilateral THA.¹⁹

A low complication rate was observed for both groups in the present investigation; however, a slight tendency toward an increased risk of minor local complications, such as haematoma and seroma, was observed in the 1B-ssTHA group. One DVT was detected postoperatively; however, no signs of pulmonary embolism were observed. The peri-prosthetic infection in the U-ssTHA group was classified as acute and was treated successfully with surgical debridement and a change of the head and inlay.

In the 1B-ssTHA group at mid-term follow-up, three deaths were noted, whereas no patients in the U-ssTHA group are yet deceased. All patients died due to cancer years after surgery, and no deaths were considered related to the surgical procedure. Therefore, no difference in

mortality rates was observed between the two groups.

According to many authors,^{4,7,10,11,20} the ASA score is a significant factor that should be considered and may be helpful as a guide for treatment indication. Because a higher ASA score is associated with more major complications,^{7,21,22} most previous investigations indicated that the 1B-THA perioperative risk was acceptable for patients with ASA Grades I or II. A recent study, including 327 patients, compared 1B-THA with unilateral THA in a selected ASA I and II population.⁴ Similar rates of mortality, complications, and implant survival were found. Thus, 1B-THA in selected patients is associated with low surgical risk and can be recommended.

In the present study, the complication rate did not differ between ASA scores. However, 89.1% of the included patients were classified as ASA I or II. Although higher ASA scores were not defined as exclusion criteria, cementless short-stem THA usage led to the careful selection of optimal patient characteristics. Given a mean patient age of 63.2 years, relatively young and potentially fit patients were included. Thus, the influence of the ASA score cannot be determined based on the present outcomes. However, no complications were observed in patients

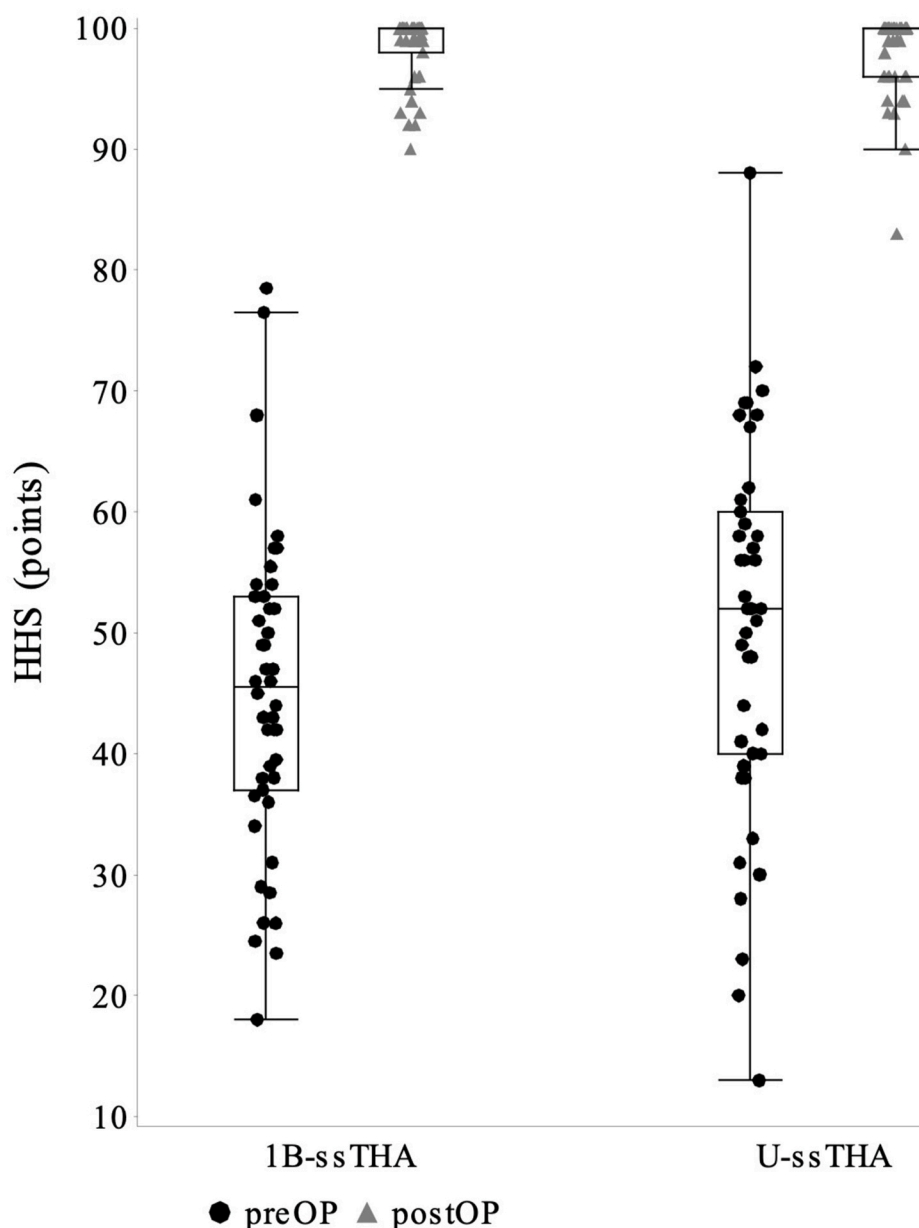


Fig. 4. Boxplot of the harris hip score.

Table 3
Restpain, load pain and satisfaction on visual analog scale (VAS) at last follow up.

FU	Mean	SD	Min	Max	p-value
Rest pain (pts)					
1B-ssTHA	0.10	0.37	0	2	0.56
U-ssTHA	0.16	0.52	0	2	
Difference	-0.07	0.69	0	2	
Load pain (pts)					
1B-ssTHA	0.60	1.00	0	3.5	0.26
U-ssTHA	0.89	1.30	0	5	
difference	-0.37	1.70	0	3.5	
Satisfaction (pts)					
1B-ssTHA	9.76	0.76	6	10	0.04
U-ssTHA	9.49	0.76	8	10	
difference	0.32	0.88	-2	2	

classified as ASA III.

The clinical results and patient-reported outcomes in both groups were highly satisfying and in line with previous studies.^{3,4,8} Post-operative satisfaction levels appeared to be even more pronounced in the 1B-ssTHA group, with a significant increase in satisfaction compared with the U-ssTHA group, possibly because the excellent outcomes for the treatment of both pathologies in 1B-THA exceeded the patients' expectations.

No aforementioned studies investigated short-stem THA. Only one previous report has compared 1B-ssTHA with U-ssTHA. Kutzner et al.²³ analysed the migration patterns of 1B-ssTHA compared with U-ssTHA using "Einzel-Bild-Roentgen-Analyse" (EBRA). This is of particular interest because pronounced subsidence has been associated with subsequent failure.²⁴ No differences in the amounts of mean stem subsidence were found, suggesting that implant fixation in 1B-ssTHA is as safe as unilateral intervention, despite full-weight bearing on both operated hips after surgery. The mid-term results of the present investigation confirm these findings.

The combination of MIS and the features of a rounded stem-design

has previously been demonstrated to be an encouraging option for bilateral hip arthritis.^{12,25} Implantation using the “round-a-corner” technique protects the greater trochanter region and minimises muscle damage.¹² The combination of MIS and short stems may facilitate patients’ rapid mobilisation, which may reduce the thromboembolic complication rate, except for one DVT.

Additionally, short-stem THA using MIS has been reported to significantly reduce blood loss and transfusion rates compared with conventional THA,²⁶ which is advantageous because, in general, increased blood loss is expected for 1B-THA compared with unilateral THA. In conventional 1B-THA, numerous previous studies have reported an increased blood transfusion requirement.^{4–6,22} However, using significant blood loss and high rates of blood transfusion have been reported even using MIS. Diwanji et al.,²⁷ in 2009, found a high mean blood transfusion rate of 3.3 units per patient after 1B-THA. Using straight stems and two-incision approach in a lateral position resulted in a mean operation time of 180.4 min, which was unreasonably long could potentially explain the distinct blood loss. In contrast, in the present study, a mean operation time of 91.9 min (range: 44–165 min) for 1B-ssTHA was documented, reducing the likelihood of blood loss. However, despite these shorter operation times, 1B-ssTHA resulted in significantly increased blood loss compared with U-ssTHA.

Recently, blood management protocols have advanced, and local and systemic tranexamic acid usage has gained popularity. Markedly reduced blood loss has been reported in recent studies by Harbison et al.²⁸ and Parcels et al.,²⁹ investigating patients who underwent 1B-THA using the MIS, direct anterior approach. In both investigations, tranexamic acid was administered perioperatively. In the present study, starting in 2010, tranexamic acid usage had not yet been implemented. Therefore, the haemoglobin drop and blood transfusion rates are expected to be reduced even further when performing the same procedures using advanced blood management protocols with the addition of local and systemic tranexamic acid.¹²

In the present study, several limitations should be acknowledged. First, this study lacks a randomised, controlled design. A randomised comparison of 1B-ssTHA versus staged bilateral short-stem THA would have been more powerful. However, a matched-pair comparative study design was chosen to provide the best possible method for achieving valid results when comparing one-stage bilateral versus unilateral procedures. Second, the study population is rather small, and a larger number of patients would have been more suitable for forming definite conclusions regarding the low incidence of complications. However, to date, 1B-ssTHA remains rarely performed, explaining the small population in the present investigation. Third, although no exclusion criteria were defined regarding ASA scores, a potential selection bias must be considered, as rather young and potentially fit patients may have been chosen as eligible for short-stem THA.

Our findings indicated that 1B-ssTHA is an effective and beneficial procedure in a selected population and may result in low rates of major complications and encouraging clinical outcomes. Mortality, complications, implant survival, and clinical outcome were similar to a matched group treated with U-ssTHA, although increased blood loss must be acknowledged in 1B-ssTHA. Using MIS and advancing blood management protocols, such as tranexamic acid administration, are recommended, particularly in 1B-ssTHA. Long-term studies remain necessary to gain further data regarding the longevity of 1B-ssTHA.

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Compliance with ethical standards

All procedures were performed in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Freiburg Ethics Review Board (FEKI 010/2071), and all patients gave permission to participate

in the study.

Trial registration

The trial registration number on German Clinical Trials Register: DRKS00012634 (retrospectively registered at 07.07.2017).

Informed consent

All patients gave their verbal and written permission to participate prior to inclusion.

Authors contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by YA, AK and KPK. The first draft of the manuscript was written by YA and KPK. JD, PR and PD were also major contributors in writing the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

KPK and PR serve as instructors for Mathys Ltd., Bettlach, Switzerland. PR also serves as medical advisor. All other authors declare that they have no competing interests.

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