

# Cementless Primary or Revision Stem in the First-time Revision Hip Arthroplasty for Aseptic Stem Loosening? A Retrospective Comparative Study.

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## Research Article

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# Abstract

## Introduction

The use of primary or revision stem during the first-time revision total hip arthroplasty (THA) procedure for aseptic stem loosening remains controversial. The aim of this study was to compare the outcome of patients that underwent revision THA with a primary or revision stem.

## Materials and Methods

We retrospectively reviewed 78 patients that received first-time revision THA for aseptic stem loosening using primary (N=28) or revision stems (N=50). The bone defects were classified as Paprosky type I or II. The mean follow-up duration was 72.3±34.7 months. The primary outcome domains included surgical complications and implant failures. The secondary outcome domains included medical complications, 30-day and 90-day readmission, and Harris hip score (HHS).

## Results

The use of revision stem was associated with higher incidence of patient having complications (60.0% vs. 32.1%,  $p=0.018$ ), including intraoperative femur fracture (28.0% vs. 7.1%,  $p=0.029$ ) and greater trochanter fracture (16.0% vs. 0%,  $p=0.045$ ), compared with the use of primary stem. The implant survival was comparable in both groups. HHS at the final follow-up was similar.

## Conclusion

With a lower risk of surgical complication and similar mid-term implant survival, cementless primary stem might be a better alternative to revision stem in the first-time revision THA for aseptic stem loosening.

# Introduction

Total hip arthroplasty (THA) is one of the most successful orthopedic procedure. With an aging population, the demand for THA is estimated to increase by 174% between 2007 and 2030 in the United States<sup>1</sup>. The increased number of primary THA procedures have led to an increase of revision THA procedures<sup>1,2</sup>. Aseptic loosening remains as one of the most common indications for revision THA<sup>2</sup>. The choice between cemented or cementless stems during the first-time revision THA procedure remains controversial, since both types of stems have led to satisfactory long-term implant survival<sup>3</sup>. When using a cementless femoral stem, primary stability is of paramount importance, which can be challenging owing to varying degrees of bone loss<sup>4</sup>. Using a primary stem during the revision procedure is associated with advantages including easier implantation, sparing of diaphysis invasion and while preserving native bone stock<sup>5,6</sup>. On the contrary, benefits of using a longer, revision stem includes increased contact area for osteointegration, which allows the bypass of metaphysis and achieve a more reliable fixation in the diaphysis<sup>4,6</sup>.

The study design of most studies that presented the outcome using either cementless primary or revision stem were single-arm, case series<sup>5,7-21</sup>. Although the mid-term implant survival of both primary (85.0% to 96.2%)<sup>7,10,21</sup> and long stem (86.0% to 97.0%)<sup>13-15,17,18</sup> were considered good to excellent, the incidence of common complications including surgical site infection (0% vs. 0-7%)<sup>7,10,12,15,21,22</sup>, periprosthetic joint infection (0.7%-5.2% vs. 0-14%)<sup>7,9,16,19</sup>, intraoperative fracture (0.7-20.2% vs. 0-64%)<sup>7,10,12,23</sup>, greater trochanter fracture (3.3% vs. 6.0-19.5%)<sup>8,13,15</sup>, periprosthetic fracture (1.4%-2.1% vs. 1-5%)<sup>5,7,11,14</sup>, stem subsidence (0% vs. 3-19.5%)<sup>7,13,15,21</sup> and dislocations (0.7-6.6% vs. 0-12%)<sup>7,8,11,17</sup> appeared to be different between primary and revision stems. However, heterogeneity across studies should be considered, such as different indications for revision procedure or types of bone defect included in each study. Therefore, a cohort study is necessary to compare the outcome between cementless primary and revision stems. To our knowledge, the only study that compared the outcome between cementless primary and revision stem was conducted by Wood et al.<sup>24</sup> The authors included 20 patients that underwent revision THA using a cementless primary (N=10) or revision stem (N=10), with mean follow-up of 12 months. The implant failure rate was higher in patients using primary stem (10% vs. 0%)<sup>24</sup>. However, this study included a mixture of indications including aseptic loosening, periprosthetic joint infection and pseudotumor. In addition, the study also had a small sample size and short follow-up duration. Therefore, we conduct this study to compare the outcome of patients that received a first-time revision THA for aseptic stem loosening using primary and revision stems. Our primary outcome domains include surgical complications and implant failure rate. The secondary outcome domains were medical complications, operation time, blood loss, transfusions, length of stay, 30-day and 90-day readmission, and patient-reported outcome. We hypothesized that the use of primary stem might be associated with fewer complications, shorter operation time, less blood loss, with similar mid-term implant survival and patient-reported outcome, compared with the use of revision stems.

## Materials And Methods

This was a retrospective, cohort study conducted in a single tertiary referral hospital of xxxxxx, xxxxxx. The ethical approval was granted by the institutional review board of our hospital. Informed consent for participation was obtained from all patients and their legal guardians. All procedures were conducted in accordance to the Declaration of Helsinki and performed according to relevant guidelines and regulations. Our study period was from January 2010 to May 2019. We obtained medical record and images from xxxxxx xxxxxx xxxxxxxx Hospital Orthopedic database. First, we collected the number of revision hip arthroplasty procedures (including total and partial revision) during this period according to xxxxxx's National Health Insurance procedure codes: "PCS-64258B, PCS-64201B". Second, we reviewed patients that underwent surgery for aseptic stem loosening according to the ICD-10-CM code: "T84.03, T84.030, T84.031, T84.038 or T84.039". We reviewed medical records and images, and included patients fulfilled the following criteria: (1) undergone the first-time revision procedure for aseptic stem loosening of primary cementless THA, (2) above 18 years of age, (3) follow-up duration more than 24 months, (4) bone defect classified as Paprosky type I or II, and (5) revision with either cementless primary or revision stems. We have excluded patients who had undergone revision procedure for (1) revision cup (N=456) or

liner only (N=71), (2) periprosthetic joint infection (N=100), (3) periprosthetic fracture (N=89), (4) recurrent dislocation (N=34), (5) broken stem (N=7), (6) revision with cemented stem (N=13), (7) with Paprosky type III or IV bone defect (N=6) (Fig. 1) Of the 78 patients included this study, 28 patients had undergone the revision procedure using a cementless primary stem (Fig. 2), while the other 50 patients had a cementless revision stem (Fig. 3). All of the procedures were performed by fellowship trained, orthopaedic surgeons. Decision of using a primary or revision stem was made based on surgeon's preference. The primary stems used were Versys (Zimmer Biomet, Warsaw, IN, USA), M/L taper (Zimmer Biomet, Warsaw, IN, USA), U2 (United, Taiwan) and Secur-fit (Stryker Orthopedics, Mahwah, IN, USA). For revision stems, we included U2 revision (United, Taiwan), Restoration HA (Stryker Orthopedics, Mahwah, IN, USA), AML (Depuy, Warsaw, IN, USA) and Wagner SL (Zimmer Biomet, Warsaw, IN, USA).

We reviewed the medical records of each patient and recorded age, sex, height, weight, body mass index, American Society of Anesthesiologists (ASA) grade, Charlson comorbidity index (CCI), type of revision procedure, surgical approach, Paprosky classification and follow-up duration. The mean age was  $62.6 \pm 14.1$  years. Twenty-three patients were female (29.5%) and 55 were male (70.5%). The mean body mass index was  $26.9 \pm 4.4$  kg/m<sup>2</sup>. Most of the patients were classified as ASA II (N=47, 60.3%) and III (N=23, 29.5%). The distribution of CCI were 0 (N=13, 16.7%), 1 (N=15, 19.2%), 2 (N=15, 19.2%), 3 (N=9, 11.5%), 4 (N=11, 14.1%) and more than 5 (N=15, 19.2%). Thirty-six patients (46.2%) underwent revision procedure for stem only, while the other 42 patients underwent revision THA (53.8%). All the patients were classified as Paprosky type I (N=67, 85.9%) or II (N=11, 14.1%) bone defect. The mean follow up duration after the revision procedure were  $72.3 \pm 34.7$  months (range, 24 to 132). (Table 1)

All the images were examined by two senior authors (xxx, xxx). The diagnosis of aseptic loosening was made based on clinical symptoms, presence of radiolucent lines in three or more Gruen zones and/or stem subsidence more than 5mm on plain radiographs<sup>25</sup>, intra-operative findings and multiple sets of intra-operative cultures. Stem subsidence of more than 5mm on serial plain radiographs was considered clinically relevant<sup>26</sup>. Paprosky classification<sup>27</sup> was used to evaluate proximal femoral bone defects. During the perioperative period, we recorded operation time, intraoperative blood loss, preoperative and postoperative hemoglobin level, estimated blood loss, transfusion rate and amount, length of stay, 30-days and 90-day readmission. After surgery, clinical condition and plain films were evaluated monthly during the first 3 months, then in 3-month intervals for the first year, and annually thereafter. We evaluated the functional outcome of all the patients using Harris hip score (HHS)<sup>28</sup> at the last follow-up visit. We recorded both surgical and medication complications, number of patient having complications, re-operation rate and implant failure rate. Common surgical complications included surgical site infection (SSI), periprosthetic joint infection (PJI), intraoperative femur fracture, greater trochanter fracture, periprosthetic femur fracture, stem subsidence, aseptic stem loosening, dislocation, and nerve injury. The distance of stem subsidence of more than 5mm was considered with clinical relevance<sup>29</sup>. Common medical complications included acute coronary syndrome, congestive heart failure, acute kidney injury (AKI), deep vein thrombosis (DVT), pulmonary embolism, cerebrovascular disease, urinary tract infection, pneumonia and gastrointestinal bleeding.

Statistical analyses were performed using SPSS version 22 (IBM Corp., Armonk, NY). Descriptive statistics were performed for all available data. The Student's *t* test was used for comparing continuous variable. The Chi-square test was used for comparing discrete variable. When one or more of the cells in the contingency table had an expected frequency of less than 5, we performed the Fisher's exact test. Time-dependent analyses for implant failure was performed using Kaplan-Meier and differences between group curves were analyzed using the Log-rank test. Statistical significance was defined as p-value < 0.05.

## Results

### *Baseline demographics*

In this study, 28 patients (35.9%) had been surgically treated with revision procedure using primary stem and 50 (64.1%) with revision stem. The age, sex, height, weight, BMI, ASA grade, CCI, index procedure, surgical approach, Paprosky classification and follow up duration after surgery were not different between the two groups. (Table 1)

### *Surgical outcomes*

The mean operation time was 168.5±87.2 (range, 55-720) minutes. Mean intraoperative blood loss was 1035±654 (range, 150-3300) milliliters. Mean preoperative and postoperative hemoglobin level were 13.1±1.7 (range, 8.6-16.9) and 10.8±1.4 (range, 7.8-14.2) g/dL, respectively. Mean estimated blood loss (EBL), calculated using the Gross and Nadler formula<sup>30,31</sup>, was 1422±689 (range, 70-3690) milliliters. Transfusion rate was 73.1% (N=57). Mean transfusion amount of pack RBC was 4±2.2 (range, 2-10) units. The mean length of stay was 7.4±2.2 (range, 4-18) days. The 30-day readmission rate was 5.1% (N=4). The reasons of 30-day readmission included dislocation (N=2), gastrointestinal bleeding (N=1) and heart failure (N=1). The 90-day readmission rate was 7.7% (N=6). The reasons of 90-day readmission included dislocation (N=3), gastrointestinal bleeding (N=1), heart failure (N=1) and deep vein thrombosis over the left leg (N=1). The mean HHS at the last follow up visit was 84.6±17.6 (range 41.8-100).

The revision stem group was associated with longer operation time (192.1±95.9 vs. 126.4±46.3, p=0.001), more intraoperative blood loss (1223±663 vs. 700±491, p<0.001), more estimated blood loss (1657±690 vs. 1003±456, p<0.001), and higher transfusion rate (86.0% vs. 50.0%, p=0.001) compared with the primary stem group. The preoperative and postoperative hemoglobin level, transfusion amount, length of stay, 30-day and 90-day readmission rate and HHS at the last follow up were not different between the two groups. (Table 2)

### *Complications and Implant failure*

The number of patients having complications were 39 (50.0%). Common surgical complications included intraoperative femur fracture 20.5% (N=16), surgical site infection 12.8% (N=10), greater trochanter fracture 10.3% (N=8), dislocation 9.0% (N=7), stem subsidence 7.7% (N=6), periprosthetic joint infection

6.4% (N=5), periprosthetic fracture 2.6% (N=2) and aseptic stem loosening 1.3% (N=1). There were 9 (11.5%) reoperation procedures. The reoperation procedures included two-stage exchange arthroplasty (N=3) and debridement (N=2) for periprosthetic joint infection, fracture fixation for periprosthetic femur fracture (N=2), open reduction for dislocation (N=1) and stem revision for aseptic stem loosening (N=1). There were 4 (5.1%) implant failure events, including periprosthetic joint infection treated with two-stage exchange arthroplasty (N=3) and aseptic stem loosening treated with stem revision (N=1).

The revision group was associated with higher rate of intraoperative fracture (28.0% vs. 7.1%,  $p=0.029$ ), greater trochanter fracture (16.0% vs. 0%,  $p=0.045$ ) and incidence of patients having complications (60.0% vs. 32.1%,  $p=0.018$ ), compared with the primary stem group. There was a trend toward a higher rate of surgical site infection in the revision stem group (18.0% vs. 3.6%,  $p=0.086$ ). None of the patient has nerve injury in both groups. The rate of reoperation and implant failure was not different between two groups. (Table 3) The overall implant survival rate were 97.4% (95% CI, 93.8-100%) and 94.0% (95% CI, 88.2-99.8%) at postoperative 2 and 5 years, respectively. (Fig. 4a) In the primary stem group, the implant survival rate at postoperative 2 and 5 years were 100% (95% CI, 100-100%) and 95.2% (95% CI, 86-100%), respectively. In the revision stem group, the implant survival rate at postoperative 2 and 5 years were 96.0% (95% CI, 90.4-100%) and 93.3% (95% CI, 85.7-100%), respectively. The implant survival was comparable in the two groups. (Log-rank test,  $p=0.629$ ). (Fig. 4b)

There were two in-hospital medical complications, including acute kidney injury (N=1) and deep vein thrombosis (N=1). The overall rate was 2.6%. The rate was similar in the two groups. (Table 4)

## Discussion

In this study, we have validated that during the first-time revision hip arthroplasty for aseptic stem loosening, the use of primary stem can lead to similar, satisfactory mid-term implant survival, and a lower incidence of overall surgical complication, intraoperative femur fracture and greater trochanter fracture, compared with the use of revision stem. Since the bone defects during the first-time revision procedure was usually small (mostly Paprosky type I or II), cementless primary stem might be an effective alternative to revision stem in this clinical scenario.

In our study, the overall incidence of patient having complication was higher in the revision stem group (60.0% vs. 32.1%,  $p=0.018$ ). Notably, the incidence of intraoperative femur fracture (28.0% vs. 7.1%,  $p=0.029$ ) and greater trochanter fracture (16.0% vs. 0%,  $p=0.045$ ) was higher. The use of a cementless long stem with a large diameter during a revision hip procedure has been validated with higher risk intraoperative fracture<sup>32,33</sup>. Moreover, increased magnitude of sagittal and coronal femoral bowing in the Asian population might further increase the risk of breach over the distal cortex<sup>34,35</sup>. The reported incidence of intraoperative fracture or greater trochanter fracture varied<sup>7,8,10,12,13,15,23</sup>. But there was a trend toward a higher rate of intraoperative fracture (0-64% vs 0.7-20.2%)<sup>7,10,12,23</sup> or greater trochanter fracture (6-19.5% vs 3.3%)<sup>8,13,15</sup> of using revision stem than the primary stem. Additional fixation procedures for the greater trochanter or femur fracture might lead to longer operation time, which might

be associated with an increased risk of short-term complications, including surgical site infection<sup>36,37</sup>. In our study, there was a trend toward a higher rate of surgical site infection in the revision group (18.0% vs. 3.6%,  $p=0.086$ ). Notably, none of these patients had developed PJI or undergone reoperation. In our study, PJI accounted for the most common reason for reoperation (N=5 of 9, 55.6%) and implant failure (N=3 of 4, 75.0%). The PJI rate was similar in the primary (7.1%) and revision stem (6.0%) groups, which was comparable with the reported PJI rate associated with the use of primary (0.7-10%)<sup>7,9,10,24</sup> or revision stem (0-14%)<sup>12,15,16,19</sup>.

In our study, the mid-term implant survival of both primary and revision stem groups was satisfactory. The 5-year implant survival rate of the primary and revision stem group were 95.2% and 93.3%, respectively, which was similar to other studies<sup>7,9,10,12,14,19</sup>. The mid-term survival rate of using primary and revision stem in revision THA procedure ranged from 95-100%<sup>7,9,10</sup> and 86-94%<sup>12,14,19</sup>, respectively. The leading causes for failure following a revision THA procedure included aseptic loosening, instability and PJI<sup>38,39</sup>. In our study, we observed reliable osteointegration with low rates of aseptic stem loosening in both primary (0%) and revision (N=1, 2.0%) stem groups, which was similar to other studies that reported mid-term results following revision THA with primary stem (0-5.2%)<sup>7,9</sup> and revision stem (0-5%)<sup>13,14,17</sup>. In addition, the incidence of stem subsidence in the primary (7.1%) and revision stem group (8.0%) was similar to the incidence reported in other studies (0-19.5%)<sup>7,13,15,21</sup>. Of the 84 patients who had the first-time revision for aseptic stem loosening, 78 (92.9%) patients had small bone defects (Paprosky type I or II) (Fig. 1). As a result, we hypothesized and validated that there might be a role for a cementless primary stem during the revision THA procedure. The potential advantages of using cementless primary stem included preservation of diaphyseal bone stock and less stress-shielding effect compared with the longer, extensively coated revision stem, in which the long-term incidence of stress-shielding around a revision stem can be up to 30%<sup>18,23,40</sup>. A cohort study with long-term follow-up is necessary to further validate these benefits.

There are some limitations of this study. First, the retrospective design of this study could have led to potential biases, including: 1) surgeries performed by multiple surgeons; 2) decision of using primary or revision stem based on surgeon's preference; 3) mixed primary and revision implant brands and 4) not a prospective, randomized design. Second, we did not routinely check bone mineral density on every patient since osteoporosis might have an impact on complications such as intra-operative femur fractures<sup>33</sup>. Despite that we did not study on senile patients with osteoporotic fracture (e.g. fracture neck fracture), the age in our cohort was ranged from 40 to 93. Osteoporosis in some of our patients should be considered an important confounding factor. Third, based on the limited number of this study, it would be underpowered to detect the difference of events with a lower incidence, such as medical complications.

## Conclusion

In conclusion, for patients that underwent first-time revision procedure for aseptic stem loosening with Paprosky type I or II defect, cementless primary stem might be a better alternative to revision stem, with

lower risk of overall surgical complication, intra-operative fracture and a similar, satisfactory mid-term implant survival.

## **Declarations**

### **Acknowledgements**

Not applicable

### **Authors' contributions**

Fu-Yuan Pai and Shang-Wen Tsai were responsible for conception and design, publication screening, acquisition of data, analysis and interpretation, and drafting and revising the manuscript. Te-Feng Arthur Chou, Hsuan-Hsiao Ma and Wei-Lin Chang were initial analysis and prepared tables. Po-Kuei Wu prepared figures. Cheng-Fong Chen, Po-Kuei Wu and Wei-Ming Chen were responsible for reviewing and revising the manuscript. All authors were involved with interpretation of the data. All authors discussed the results and commented on the manuscript. The author(s) read and approved the final manuscript.

### **Competing interests**

The authors have no conflicts of interest to declare that are relevant to the content of this article.

### **Availability of data and material**

All data generated or analysed during this study are included in this published article and available upon request.

### **Ethics declarations**

#### ***Ethical approval***

The study was approved by the ethical committee of Taipei Veterans General Hospital.

#### ***Informed consent***

Informed consent was obtained from all patients and their families for publication of this study and any accompanying images.

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## Tables

### Table 1 Patient demographics

	Overall (N=78)	Primary stem (N=28)	Revision stem (N=50)	P-value
Age	62.6±14.1 (40-93)	63.5±13.1 (42-83)	62.1±14.8 (40-93)	0.690
Sex				0.053
Female	23(29.5%)	12(42.9%)	11(22%)	
Male	55(70.5%)	16(57.1%)	39(78%)	
Height (m)	1.61±0.09 (1.40-1.80)	1.61±0.09 (1.44-1.80)	1.61±0.09 (1.40-1.79)	0.961
Weight (kg)	70.2±14.2 (47.5-115.1)	71.4±13.8 (54.0-115.1)	69.5±14.4 (47.5-111.0)	0.565
Body mass index (kg/m <sup>2</sup> )	26.9±4.4 (18.2-39.7)	27.3±4.1 (18.2-38.5)	26.6±4.6 (19.4-36.7)	0.494
ASA grade				0.189
1	8(10.3%)	5(17.9%)	3(6.0%)	
2	47(60.3%)	14(50.0%)	33(66.0%)	
3	23(29.5%)	9(32.1%)	14(28.0%)	
Charlson comorbidity index				0.534
0	13(16.7%)	4(14.3%)	9(18.0%)	
1	15(19.2%)	7(25.0%)	8(16.0%)	
2	15(19.2%)	5(17.9%)	10(20.0%)	
3	9(11.5%)	1(3.6%)	8(16.0%)	
4	11(14.1%)	4(14.3%)	7(14.0%)	
5+	15(19.2%)	7(25.0%)	8(16.0%)	
Revision procedure				0.054
Revision stem only	36(46.2%)	17(60.7%)	19(38.0%)	
Revision THA	42(53.8%)	11(39.3%)	31(62.0%)	
Surgical approach				0.818
Lateral transgluteal	63(80.8%)	23(82.1%)	40(80.0%)	
Posterolateral	15(19.2%)	5(17.9%)	10(20.0%)	

Paprosky classification				0.186
I	67(85.9%)	26(92.9%)	41(82.0%)	
II	11(14.1%)	2(7.1%)	9(18.0%)	
Follow-up duration (months)	72.3±34.7	75.1±36.6	70.7±33.8	0.589
	(24-132)	(24-132)	(24-129)	

ASA: American Society of Anesthesiologists (ASA) grade

**Table 2 Surgical outcome in both intervention groups**

	Overall (N=78)	Primary stem (N=28)	Revision stem (N=50)	P- value
Operation time (mins)	168.5±87.2 (55-720)	126.4±46.3 (55-220)	192.1±95.9 (90-720)	0.001
Intraoperative blood loss (ml)	1035±654 (150-3300)	700±491 (150-2300)	1223±663 (150-3300)	<0.001
Preoperative hemoglobin level (g/dL)	13.1±1.7 (8.6-16.9)	13.0±1.7 (8.6-16.9)	13.1±1.6 (9.4-16.6)	0.825
Postoperative hemoglobin level (g/dL)	10.8±1.4 (7.8-14.2)	11.1±1.5 (7.9-14.2)	10.6±1.4 (7.8-13.7)	0.137
Estimated blood loss (ml)	1422±689 (70-3690)	1003±456 (70-1790)	1657±690 (260-3690)	<0.001
Transfusion rate (%)	57 (73.1%)	14 (50.0%)	43 (86.0%)	0.001
Transfusion amount (unit)	4.0±2.2 (2-10)	3.1±1.6 (2-6)	4.3±2.4 (2-10)	0.098
Length of stay (day)	7.4±2.9 (4-18)	7.2±3.7 (4-18)	7.5±2.3 (4-14)	0.656
30-day readmission (%)	4 (5.1%)	0 (0%)	4 (8.0%)	0.291
90-day readmission (%)	6 (7.7%)	1 (3.6%)	5 (10.0%)	0.411
HHS at the last follow up	84.6±17.6 (41.8-100)	83.9±17.8 (47.3-100)	85.0±17.7 (41.8-100)	0.816

*30-day readmission:* dislocation (N=2), gastrointestinal bleeding (N=1), congestive heart failure (N=1).

*90-day readmission:* dislocation (N=3, 1 in primary stem group), gastrointestinal bleeding and pneumonia (N=1, same patient, two events) (N=1), congestive heart failure (N=1), deep vein thrombosis (N=1).

**Table 3 Surgical complications, reoperations, implant failures and in-hospital medical complications**

	Overall (N=78)	Primary stem (N=28)	Revision stem (N=50)	P- value
Surgical complication (%)				
Surgical site infection	10 (12.8%)	1 (3.6%)	9 (18.0%)	0.086
Periprosthetic joint infection	5 (6.4%)	2 (7.1%)	3 (6.0%)	1.000
Intraoperative femur fracture	16 (20.5%)	2 (7.1%)	14 (28.0%)	0.029
Greater trochanter fracture	8 (10.3%)	0	8 (16.0%)	0.045
Periprosthetic femur fracture	2 (2.6%)	0	2 (4.0%)	0.534
Stem subsidence	6 (7.7%)	2 (7.1%)	4 (8.0%)	1.000
Aseptic stem loosening	1 (1.3%)	0	1(2.0%)	1.000
Dislocation	7 (9.0%)	2 (7.1%)	5 (10.0%)	1.000
Nerve injury	0	0	0	-
Number of patient having surgical complications	39(50.0%)	9(32.1%)	30(60.0%)	0.018
Reoperation (%)	9 (11.5%)	2 (7.1%)	7 (14.0%)	0.477
Implant failure (%)	4 (5.1%)	1 (3.6%)	3 (6.0%)	1.000

*Reoperation:* periprosthetic joint infection (N=5, 2 in primary stem group), periprosthetic femur fracture (N=2), dislocation (N=1), stem aseptic loosening (N=1)

*Implant failure:* periprosthetic joint infection (N=3, 1 in primary stem group), stem aseptic loosening (N=1)

#### **Table 4 In-hospital medical complications**

	Overall (N=78)	Primary stem (N=28)	Revision stem (N=50)	P-value
Medical complication (%)				
Acute coronary syndrome	0	0	0	-
Congestive heart failure	0	0	0	-
Acute kidney injury	1 (1.3%)	0	1 (2.0%)	1.000
Deep vein thrombosis	1 (1.3%)	1(3.6%)	0	0.359
Pulmonary embolism	0	0	0	-
Cerebrovascular disease	0	0	0	-
Urinary tract infection	0	0	0	-
Pneumonia	0	0	0	-
Gastrointestinal bleeding	0	0	0	-
Number of patient having complications	2 (2.6%)	1 (3.6%)	1 (2.0%)	1.000

## Figures

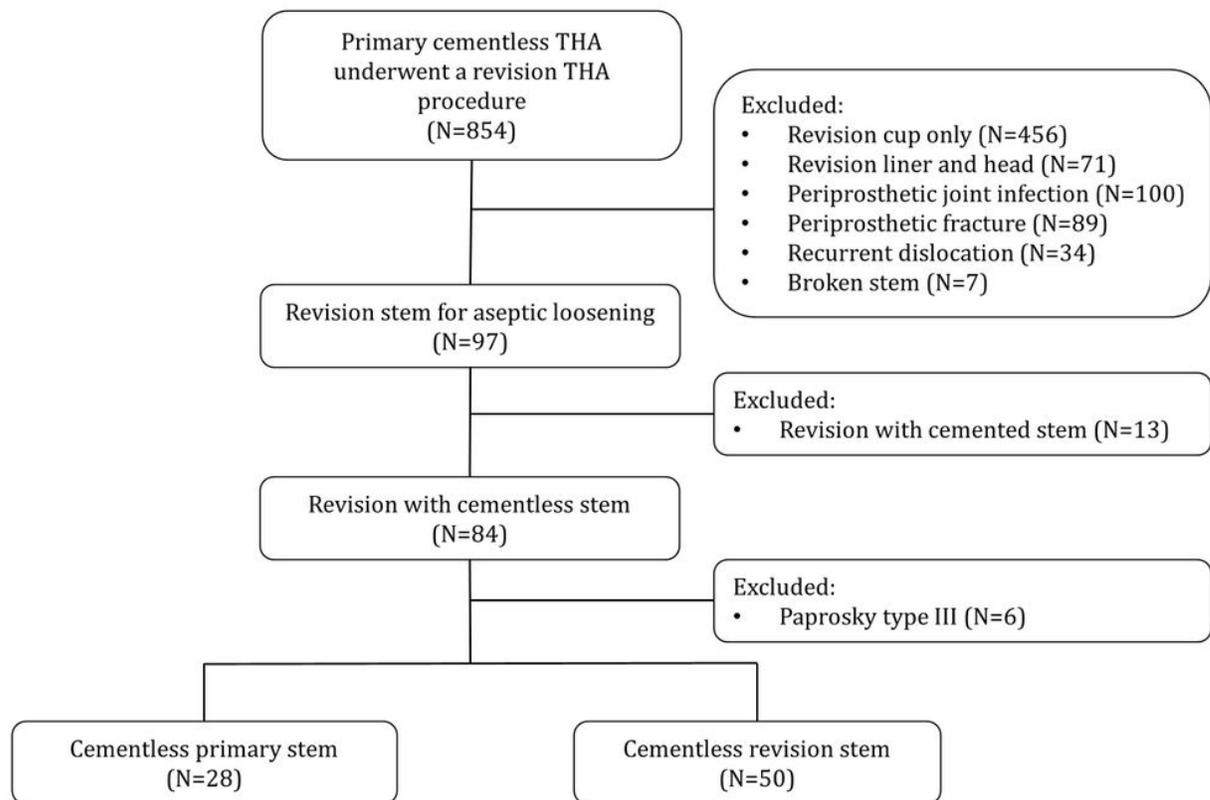
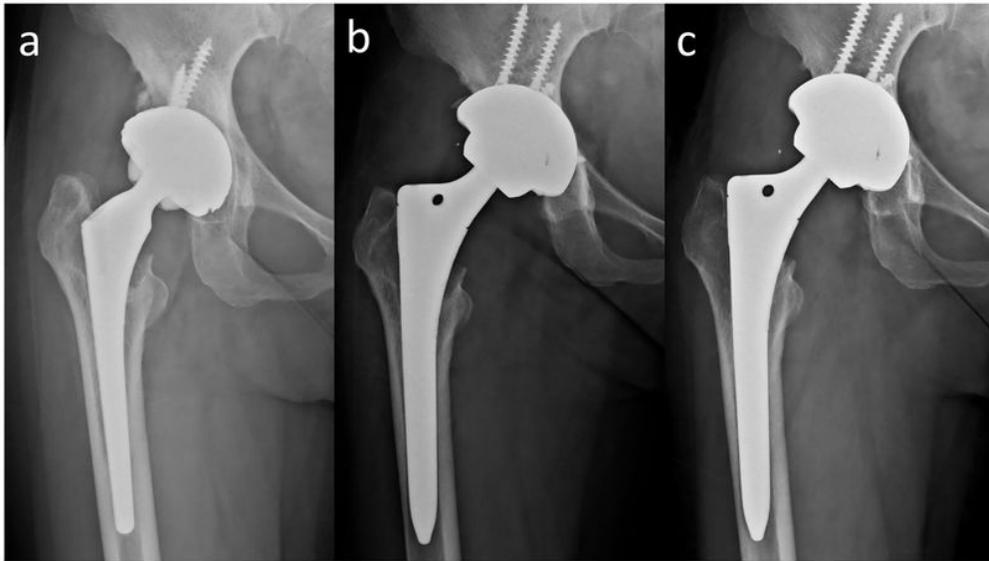


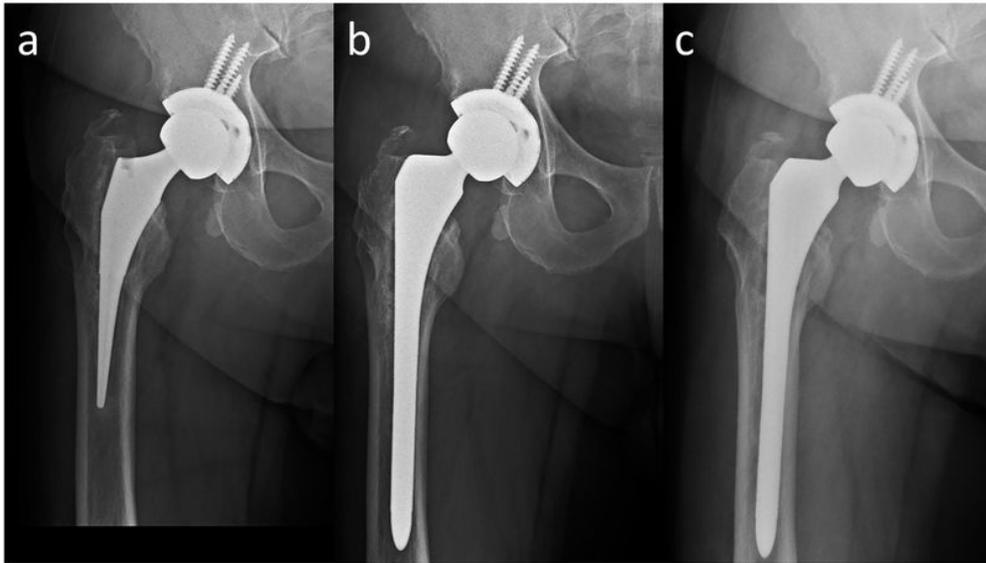
Figure 1

CONSORT diagram.



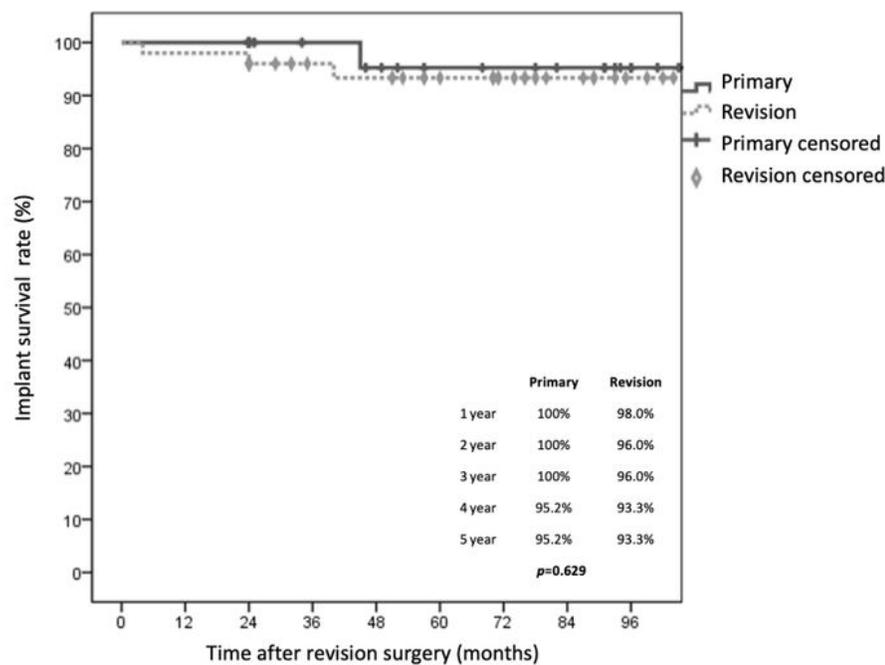
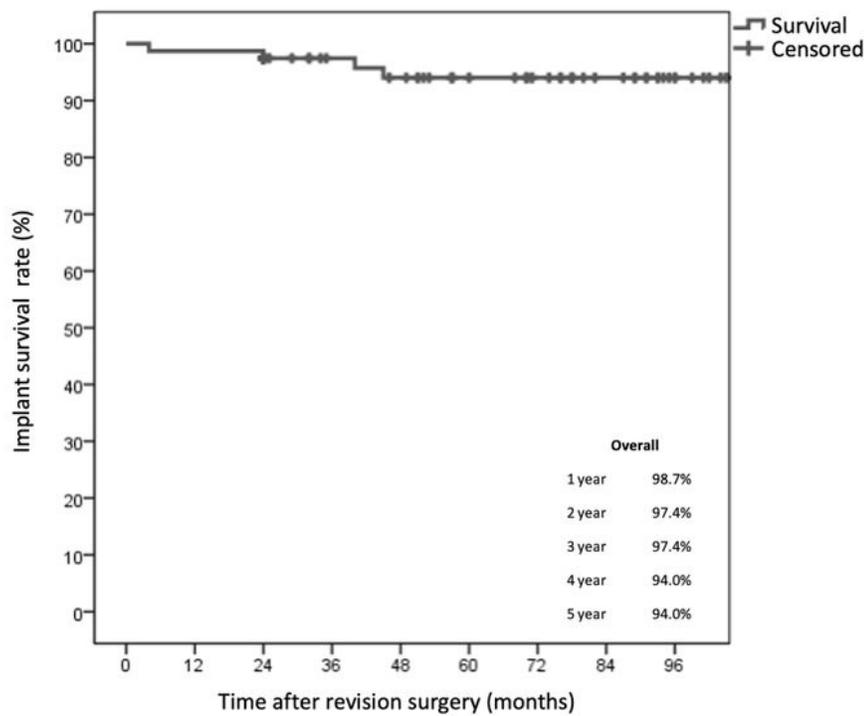
**Figure 2**

54-year-old female with aseptic stem loosening, Paprosky type II, (a) preoperative radiograph, (b) revision total hip arthroplasty procedure using primary, metaphyseal coated stem, immediate postoperative radiograph, (c) postoperative 24-month.



**Figure 3**

55-year-old male with aseptic stem loosening, Paprosky type II, (a) preoperative radiograph, (b) revision procedure using extensively coated, diaphyseal filling revision stem, immediate postoperative radiograph, (c) postoperative 24-month.



**Figure 4**

(a) Overall implant survival rate: 97.4% (95% CI, 93.8-100%) and 94.0% (95% CI, 88.2-99.8%) at postoperative 2 and 5 years, respectively. (b) Implant survival rate (primary stem): 100% and 95.2% (95% CI, 86-100%) at postoperative 2 and 5 years, respectively. Implant survival rate (revision stem): 96.0% (95% CI, 90.4-100%) and 93.3% (95% CI, 85.7-100%) at postoperative 2 and 5 years, respectively.