

# A follow-up study of hip arthroplasty in patients with chronic renal failure on dialysis

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## Research article

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## Abstract

**Background** Although hip arthroplasty has become increasingly common, its radiological and clinical outcomes in chronic renal failure patients remain unclear. This study analyzed the outcomes of hip arthroplasty in patients with chronic renal failure undergoing dialysis. **Methods** Of 2,364 hips undergoing total hip arthroplasty or bipolar hemiarthroplasty between January 2003 and December 2017, data pertaining to 37 hips of patients with chronic renal failure undergoing dialysis (16 men, 21 women) were retrospectively examined. We analyzed the radiological and clinical outcomes of hip arthroplasty, as well as the occurrence of local and general complications (particularly the time of their occurrence) during follow-up and their association with dialysis duration.

**Results** The mean patient age was  $60.6 \pm 13.5$  years, and the mean follow-up duration was  $36.6 \pm 27.2$  months. The mean T-value indicating bone mineral density was  $-2.62 \pm 1.15$ , with osteoporosis noted in 20 cases. Except for 1 case with infection-induced change in acetabular cup tilt, all cases of total hip arthroplasty with cementless acetabular cup implant exhibited excellent radiographic outcomes. The cementless proximally coated femoral stem was used in all 25 cases of total hip arthroplasty and 7 out of 12 cases of bipolar hemiarthroplasty. Changes in the alignment of femoral stems, subsidence, osteolysis, and loosening were not observed. On clinical assessment, 33 patients received an "excellent" or "good" Harris hip score. Within 1 year postoperatively, complications developed in 18 patients, and some patients exhibited more than 1 complication. More than 1 year after surgery, general complications developed in 12 patients; however, no patient experienced local complications.

**Conclusions** Hip arthroplasty in chronic renal failure patients on dialysis showed excellent radiological and satisfactory clinical outcomes; however, it may be associated with various postoperative complications. Therefore, meticulous preoperative treatment planning and overall postoperative management are required to reduce the risk of complications.

## Introduction

The incidence of chronic renal failure (CRF) has been steadily increasing, and as a result an increasing number of CRF patients are experiencing hip joint disorders [1, 2], with a reported increase in the incidence of hip diseases in CRF patients. Alem et al. [3] estimated the incidence of femoral neck fractures in patients on dialysis to be 7 (men) and 13 (women) per 1,000 person-years, which was 4 times higher than that in the control group. In particular, CRF patients on dialysis often have poorer bone quality than others, demonstrate a higher association with comorbidities (including diabetes mellitus and hypertension), and are often immunosuppressed, all of which can lead to poor surgical outcomes and eventual poor prognosis following hip arthroplasty [3, 4]. Despite the high risks of operative treatment in CRF patients on dialysis, debilitating joint conditions, including hip osteoarthritis, femoral head osteonecrosis, and traumatic hip fractures (e.g., femoral neck fracture), may necessitate surgical management, and these often constitute the indications for hip arthroplasty in these patients [2, 5 – 8]. Therefore, while hip replacement has become more common in patients with chronic kidney disease (CKD), studies on its outcomes have reported varying success rates [2, 5 – 11].

Suitable stable fixation methods, considering the poor bone quality in CRF patients on dialysis, remain unclear, and studies that have closely investigated such methods have insufficient statistical power. Moreover, existing studies have not focused on clinical analysis and complications following hip replacement. Therefore, we analyzed the radiological and clinical outcomes and the complications and their time of occurrence in CRF patients on dialysis, who were treated with total hip arthroplasty (THA) or bipolar hemiarthroplasty (BH) using a cementless acetabular cup with a proximally coated or cemented stem. The ultimate aim was to analyze important surgical outcomes and their association with dialysis duration.

## Methods

### Patients

Overall, 2,364 hips underwent THA and BH at our hospital between January 2003 and December 2017. There were 187 CRF patients, including those undergoing hemodialysis or peritoneal dialysis; of these, 153 patients who were not on dialysis were excluded. Finally, data from 37 hips of 34 patients (3 patients underwent bilateral treatment) were prospectively collected and retrospectively analyzed.

Data on associated comorbidities were collated from medical records, including history taken at the time of admission and preoperative evaluation. In all 37 cases, preoperative dual-energy X-ray absorptiometry was performed, and bone mineral density was measured to evaluate bone quality. The preoperative risk was evaluated according to the American Society of Anesthesiologists guidelines [12]. This study was approved by our institutional review board, and written informed consent was obtained from all the patients included.

# Surgical Technique and Postoperative Rehabilitation

Preoperatively, all patients regularly underwent dialysis 3 times a week, and their serum creatinine and electrolyte levels were monitored in coordination with the treating nephrologist. Dialysis was also continued at the same frequency, postoperatively. The antibiotic dosage to be administered was determined based on the kidney function, and the surgical drain was removed on postoperative day 2 for all patients.

Patients younger than 75 years of age with preserved cognition and ambulation underwent THA, while those older than 75 years of age with poor cognition and ambulation underwent BH. True anteroposterior and lateral radiographs were obtained by placing a radio-opaque metal rod (length, 100 mm) under the fluoroscope to minimize magnification and avoid inaccurate measurements of bony landmarks. Two senior surgeons performed the operative procedure in all patients. A preoperative on-screen template [13] was utilized and reviewed in all cases to accurately determine the size of the prosthetic implant and to correct any discrepancies in patients' leg length measurements. A posterolateral approach was used, and posterior soft tissue repair was performed for all patients [14].

In THA, either the hemispheric cementless Trilogy (Zimmer, Warsaw, IN, USA) or the Continuum (Zimmer) acetabular cup was used for implantation. The cup was reamed to a size 1–2 mm smaller and press-fitted into the acetabulum to achieve firm fixation. When necessary, acetabular screws were additionally used for fixation. An adequately sized prosthetic head was chosen, considering the liner thickness of the acetabular cup. The Trilogy cup has a highly cross-linked polyethylene liner with a metal or ceramic prosthetic head, while both the liner and head are made of ceramic in the Continuum cup. Furthermore, a tapered fiber metal (Zimmer) or the VerSys Heritage stem (Zimmer) (with a centralizer in the distal portion) was used as the cementless and cemented femoral stem, respectively. The cemented stem was used in cases wherein cementless stem fixation could not be achieved owing to the wide femoral isthmus or poor bone quality. The cemented stem was also substituted intraoperatively when the cementless stem could not be press-fitted adequately to achieve sufficient initial stability. To achieve a firm press-fitting of the cementless femoral stem, the implant stability was tested by inserting and rotating a rasp of the largest possible size that could be accommodated into the femur.

During postoperative rehabilitation, quadriceps exercises were initiated on postoperative day 1, and partial weight-bearing ambulation, using a clutch, was started on postoperative day 2. Complete weight-bearing ambulation was allowed within < 3 months of surgery for all patients. To prevent venous thromboembolism, low-molecular-weight heparin (LMWH) was administered to all patients, excluding those with known endogenous bleeding risks. LMWH was administered to patients with hip fracture before surgery up to 2 weeks after surgery (i.e., until discharge); for patients who underwent elective surgery, including those with osteoarthritis or osteonecrosis [15 – 17], LMWH was also administered before surgery up to 2 weeks after surgery.

## Radiological Assessment

Postoperative outcomes, including osteolysis and migration, subsidence, or loosening of the prosthesis, and stability of the acetabular cup and femoral stem, were analyzed through follow-up radiological assessments.

In post-THA patients, vertical migration of the acetabular cup was assessed by measuring the change in the vertical distance between the center of rotation (COR) of the cup and both ends of the teardrop. The horizontal migration was evaluated by estimating the change in length of the horizontal distance between the vertical lines passing from the COR of the cup and onwards through the center of the teardrop. Differences in vertical and horizontal migration > 2 mm between the final follow-up images and the postoperative plain radiographs associated with > 5° change in pelvic tilt were considered to indicate significant prosthesis loosening. Furthermore, prosthesis loosening was considered to have occurred when postoperative imaging showed significant vertical or horizontal migration, change in inclination of the acetabular cup, or continuous, progressively widening radiolucent lines of > 2 mm thickness around the acetabular cup [18]. The presence of acetabular erosion and proximal migration of the cup were considered to indicate loosening in patients who underwent BH.

During the preoperative assessment of the femoral stem, plain radiographs were used to classify the proximal femoral form according to the Dorr classification [19]. Postoperatively, stable fixation of the cementless prosthetic femoral stem was evaluated by examining the bone ingrowth, stability of the fibrous fixation, and the degree of instability of the prosthesis during the final follow-up, as suggested by Engh et al. [20]. As described elsewhere [21, 22], the subsidence of the femoral stem was measured as the distance from the medial and proximal notches on the microporous material to the proximal surface of the lesser trochanter and was considered to be significant when the difference between the two was > 5 mm and when radiolucent lines were observed in > 50% of each area on the implant surface. Osteolysis was defined as a localized cystic erosion of dilated cortical bone of diameter > 5 mm [23]. Progressive subsidence or migration of the femoral stem or radiolucent lines surrounding the femoral stem thicker than 2 mm indicated radiological loosening of the femoral

stem [20]. The Harris classification [24] was used for evaluating the cemented femoral stem, and definite loosening was defined by radiological signs, including subsidence of the femoral stem, fracture involving the cement or stem, and progression of radiolucent lines at the interface between the cement and femoral stem. Probable loosening was defined as progressive radiolucent lines observed at the overall interface of the cement and femoral stem, and possible loosening was defined as radiolucent lines covering 50–100% of the interface between the two.

## Clinical Assessment

The Harris hip score [25] was used to evaluate clinical function. Clinical outcomes were assessed preoperatively and at the final follow-up. The preoperative Harris hip scores of patients with hip fractures were excluded. The final follow-up score was assessed. The scores ranged from 0 to 100, with 90–100, 80–89, 70–79, and < 70 points indicating excellent, good, fair, and poor outcomes, respectively.

Clinical analysis was performed by reviewing patients' medical records regarding the length of hospital stay, operative duration, blood loss volume, requirement for intraoperative transfusion, preoperative dialysis duration, and total dialysis duration.

## Assessment of Complications

Complications were classified as local and general complications and further categorized into early (occurring at < 1 year postoperatively) and late (occurring after 1 year postoperatively) complications. Local complications included surgical site infections, periprosthetic fractures, and dislocations that required additional postoperative treatment. General complications included death, obvious worsening of underlying comorbidities, venous thromboembolism, cardiopulmonary or urinary complications, and multi-organ failure. Furthermore, we analyzed the association of the occurrence of general and local complications with the preoperative and total dialysis durations.

## Statistical Analysis

Study participants' data are summarized as mean  $\pm$  standard deviation for continuous variables and as frequency with percentage for categorical variables. Differences in clinical values at different time points were analyzed using the Mann-Whitney test. The correlation between dialysis duration and occurrence of complications was analyzed using the Spearman correlation coefficient.

All statistical analyses were performed using SPSS software version 18 (IBM Corp., Armonk, NY, USA). P-values < 0.05 were considered statistically significant.

## Results

### Patients

The mean age of patients was  $60.6 \pm 13.5$  years (range, 20–81 years), and the total study group included 15 men (44.1%) and 19 women (55.9%). The mean follow-up duration (except in patients who died early) was  $36.6 \pm 27.2$  months (range, 12–107 months). Altogether, there were 31 patients of hemodialysis and 3 patients of peritoneal dialysis. The mean preoperative dialysis duration was  $34.2 \pm 42.0$  months (range, 1–180 months), and the mean total dialysis duration was  $57.1 \pm 46.8$  months (range, 13–198 months). A cementless proximally coated femoral stem was used in all 25 cases of THA (100%) and a cemented femoral stem was used in 5 out of 12 cases (41.7%) of BH. The mean T-value indicating bone mineral density was  $-2.62 \pm 1.15$  (range, -4.1 to -0.5). Osteoporosis (defined as a T-value of < -2.5) was observed in 20 cases (54.1%). Furthermore, 31 out of 34 patients had concurrent comorbidities other than CRF (Table 1).

Table 1  
Demographic data of patients in the study

	No. of cases
Type of operation	
Total hip arthroplasty	25
Bipolar hemiarthroplasty	12
Diagnosis	
Femoral neck fracture	24
Femoral head osteonecrosis	8
Hip osteoarthritis	3
Hip rheumatoid arthritis	2
Bone mineral density (T-score)*	
Normal (T-score >-1.0)	8
Osteopenia (T-score: -1.0 to -2.5)	9
Osteoporosis (T-score ≤-2.5)	20
Comorbidities	
Hypertension	28
Diabetes mellitus	21
Cerebrovascular disease	9
Coronary artery occlusive disease	8
Liver disease	5
Lung disease	2
Rheumatoid arthritis	2
Prostate cancer	1
Schizophrenia	1
Dementia	1
ASA score	
I	0
II	15
III	21
IV	1
*Estimated using dual-energy X-ray absorptiometry. ASA: American Society of Anesthesiologists, no: number	

## Radiological Outcomes

Detailed results are presented in Table 2. No vertical or horizontal migration of the acetabular cup or severe osteolysis around the acetabular cup was observed at follow-up. In 1 case (2.9%), a change in the acetabular cup angle was observed, which may be attributable to surgical site infection (Fig. 1A–C). In all other cases, there was no progression of the radiolucent lines beyond a width of 2 mm. No signs of complications after BH were noted. In the evaluation of femoral stem stability, 21 out of 29 cases (72.4%) operated on using the cementless stem showed stable bone ingrowth, whereas 8 cases (27.6%) demonstrated stable fibrous fixation. Unstable fixation or loosening was not observed in any case during follow-up, whereas stable fixation was achieved in all 5 cases (100%) operated on using the cemented stem, with no loosening, migration, or subsidence of the stem detected postoperatively.

Table 2  
Radiological outcomes\*

	No. of cases
Acetabular cup	34
Total hip arthroplasty	23
Migration	0
Tilting	1
Osteolysis	0
Bipolar hemiarthroplasty	11
Proximal migration	0
Acetabular erosion	0
Femoral stem	
Dorr classification	37
A	3
B	25
C	9
Final follow-up	34
Stable (cementless)	29
Bone ingrowth	21
Fibrous fixation	8
Stable (cemented)	5
Unstable (migration, subsidence)	0
*Dorr classification score evaluated using preoperative plain radiographs; other radiological outcomes were analyzed for all patients, excluding 3 who died within 1 year postoperatively. No.: number	

## Clinical Outcomes

The mean Harris hip scores were  $46.7 \pm 12.7$  preoperatively (excluding patients with hip fractures) and  $92.0 \pm 6.2$  at the final follow-up, thus showing a statistically significant difference ( $P < 0.001$ ). The mean final follow-up score, including those with hip fractures, was 91.8 (excellent; Table 3).

Table 3  
Clinical outcomes

Clinical	Preoperatively <sup>#</sup>	At the final follow-up	p*
Harris hip score	$46.7 \pm 12.7$	$92.0 \pm 6.2$	$< 0.001$
Excellent (90–100)		31	
Good (80–89)		2	
Fair (70–79)		1	
Poor		0	
*P-values were derived from the Mann-Whitney test.			

Clinical outcomes were analyzed for all hips, excluding those of 3 patients who died within 1 year postoperatively.

#The mean preoperative Harris hip score was not obtained in fracture patients.

The average hospitalization duration was  $25.4 \pm 10.5$  days (range, 10–63 days). The mean operative time was  $103.7 \pm 28.2$  min (range, 90–225 min). The mean intraoperative blood loss volume was  $310.3 \pm 196.1$  ml (range, 100–1100 ml), and there were 17 cases (45.9%) requiring blood transfusion. No patient complained of persistent inguinal or thigh pain postoperatively.

## Complications

Complications were observed within 1 year of surgery in 18 patients (52.9%) with 3 cases of local complications (1 surgical site infection, 2 postoperative dislocations). Patients with dislocations (one having schizophrenia) were conservatively treated. No recurrence was observed. No periprosthetic fractures or other local complications were noted.

Some patients showed more than 1 complication: acute kidney insufficiency (AKI) in 7 patients (38.9%, 20.6% of the total), urinary tract infections in 7 (38.9%, 20.6% of the total), pneumonia in 2 (11.1%, 5.9% of the total), atelectasis in 2 (11.1%, 5.9% of the total), septic shock in 1 (5.6%, 2.9% of the total), cardiac arrest in 1 (5.6%, 2.9% of the total), venous thromboembolism in 1 (5.6%, 2.9% of the total), and pulmonary edema in 2 (5.6%, 5.9% of the total). Three patients died (1 because of acute-on-CRF, 1 because of septic shock, and the other because of cardiac arrest) (Table 4).

Table 4  
Incidence of early complications in patients undergoing hemodialysis after hip arthroplasty

Early complications												
	Sex/Age (years)	SSI	Dislocation	Death	VTE	AKI	Septic shock	Cardiac arrest	Pneumonia	UTI	Other infections	Other complications
1	F/47									0		
2	F/51			0	0	0						
3	F/56					0						
4	M/57			0			0					
5	F/57										0 (infectious colitis)	
6	F/57								0			0 (atelectasis)
7	F/64									0		
8	M/64		0			0						
9	F/65									0		
10	M/68		0									0 (atelectasis)
11	F/69					0				0	0 (PMC)	
12	M/69					0						
13	M/71	0								0		
14	M/74			0				0				0 (pulmonary edema)
15	F/74									0		
16	F/75					0						0 (pulmonary edema)
17	F/79					0						
18	M/81								0	0		
Total		1	2	3	1	7	1	1	2	7	2	4
0: complication occurred, F: female, M: male, SSI: surgical site infection, VTE: venous thromboembolism, AKI: acute kidney insufficiency, UTI: urinary tract infection, PMC: pseudomembranous colitis												

No correlation between the occurrence of postoperative complications and preoperative dialysis duration was observed (P = 0.227). However, the occurrence of complications was positively correlated with the total dialysis duration (r = 0.477, P = 0.001) (Fig. 2A, B).

Sex/Age (years)	Late complications							
	Death	AKI	Septic shock	Cardiac arrest	Pneumonia	UTI	Other infections	Other complications
1 F/47						O		
2 F/56	O		O			O		
3 F/56								O (gastric ulcer bleeding)
4 F/57	O	O	O		O		O (ischemic colitis)	
5 F/57					O	O		
6 F/60	O			O				
7 F/64	O	O					O	O (acute cholecystitis)
8 F/65						O		
9 M/68	O	O						
10 M/68					O			
11 F/74						O		
12 F/75		O						O (pulmonary edema)
<b>Total</b>	5	4	2	1	3	6	1	3

**Table 5.** Incidence of late complications in patients undergoing hemodialysis after hip arthroplasty

O: complication occurred, F: female, M: male, AKI: acute kidney insufficiency, UTI: urinary tract infection

## Discussion

Femoral stem stability and satisfactory implantation of the acetabular cup were achieved in patients on dialysis who underwent hip arthroplasty. However, during follow-up, which lasted for an average of  $36.6 \pm 27.2$  months, 8 patients died, and significant complications were observed in 21 patients. Moreover, the total dialysis duration was associated with the occurrence of complications indicating that general complications, including death, could occur after hip arthroplasty in CRF patients on dialysis, even when the orthopedic outcome of the operative procedure is outstanding.

Deposition of peri-implant beta 2-microglobulin amyloid in the pseudocapsule and pseudomembranous tissue in chronic hemodialysis patients results in corresponding loosening of the prosthesis [26]. Furthermore, failure of THA in patients on hemodialysis is attributable to loosening of the prosthesis due to poor bone quality and high osteoclast activity, secondary to an increase in serum parathyroid hormone level in CRF patients, which leads to increased bone resorption and destabilization of bone-implant fixation [27]. Nagoya et al. [10] used an extensively porous-coated cementless stem in dialysis patients undergoing hip arthroplasty and reported a 100% fixation rate with bone ingrowth. In this study, although many patients had osteoporosis, the use of proximally porous-coated cementless stem or cemented stem enabled firm fixation.

The main goal of hip arthroplasty is to restore normal ambulation and physical activity, which is known to be difficult in CRF patients [3, 4]. In this study, clinical evaluation during follow-up showed satisfactory improvement. In 1 case (2.9%) with a fair outcome, general weakness from worsening of the CRF led to difficulty in ambulation > 3 years postoperatively. However, clinical scores represent the outcome at the time of scoring and not the long-term progressive outcomes. Patients on dialysis often have comorbidities, such as bleeding tendencies, infections, and vascular diseases, in addition to the CKD; hence, worsening of these underlying conditions and other associated causes may also lead to death [7, 28]. We observed a total of 8 fatalities, with 3 occurring within 1 year. Therefore, mortality in patients with hip arthroplasty undergoing dialysis could be high and appears to increase with worsening of the underlying diseases and infections.

Generally, immunosuppression (from chronic dialysis), malnutrition, and lack of erythropoietin are known to increase the incidence of infection around the surgical and prosthesis site [7 – 9, 28, 29]. Naito et al. [8] reported surgical site infection in 12% of patients who underwent hip arthroplasty. Lieberman et al. [7] and Sakalkale et al. [5] reported the occurrence of postoperative infections in 19% and 13% of their patients, respectively. These rates are much higher than the 5-year post-THA infection rate in the general population, which ranges between 0.2% and 1.1% [30]. In this study, surgical site infection was observed in 1 patient at < 1 year postoperatively, which improved with antibiotic administration and local debridement. The same patient showed acetabular cup tilting, which was considered to have been caused by the recurrence of infection at 7 months postoperatively, suggesting that the superficial infection had progressed to deep infection. Considering that a general infection was observed in 12 of the 21 patients with complications (57.1%), patients on dialysis appear to be susceptible to infections, which can often be progressive. Although hip arthroplasty may lead to acceptable orthopedic outcomes in patients on dialysis, more caution is indicated with regard to general complications. Hip arthroplasty may be considered an appropriate treatment alternative, if conducted after a comprehensive general preoperative evaluation.

This study had some limitations. The study had a retrospective design and included the follow-up data of a relatively small sample of patients on dialysis. Therefore, it is difficult to attribute general clinical significance to the results of the study. Moreover, a comparison with a control group was not performed. A comparison of BH and THA conducted under the same conditions would be useful to overcome this limitation. Therefore, prospective, comparative studies with larger patient groups are indicated in the future to validate our findings.

## Conclusion

Our findings suggest that thorough preoperative planning and appropriate holistic postoperative management are indicated to decrease the occurrence of general complications in post-THA patients on dialysis.

## Abbreviations

AKI: acute kidney insufficiency

BH: bipolar hemiarthroplasty

CKD: chronic kidney disease

COR: center of rotation

CRF: chronic renal failure

THA: total hip arthroplasty

## Declarations

### Ethics approval and consent to participate

The study was approved by our institutional review board of our hospital (Approval No. 05-2020-024), and written informed consent was obtained from all the patients included.

### Consent for publication

Not applicable.

### Availability of data and materials

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

### Competing interests

The authors declare that they have no competing interests.

### Funding

Not applicable.

### Authors' contributions

S.M.L. contributed greatly to the manuscript preparation.

K.T.S. analyzed and interpreted patient data and performed surgery.

W.C.S. analyzed and interpreted patient data.

Y.K.O. collected data.

S.H.W. analyzed and interpreted patient data.

All authors read and approved the final manuscript

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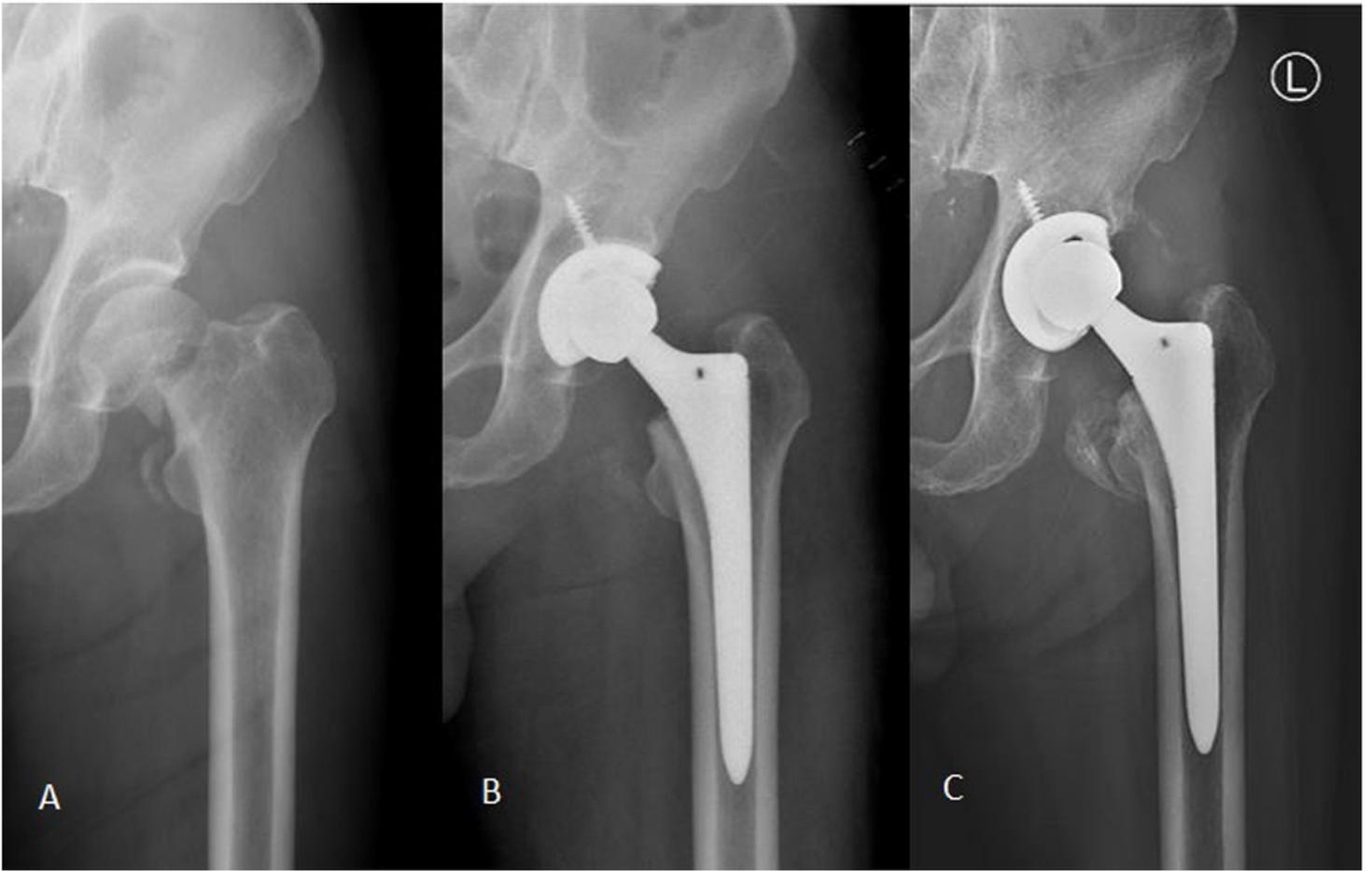
Not applicable.

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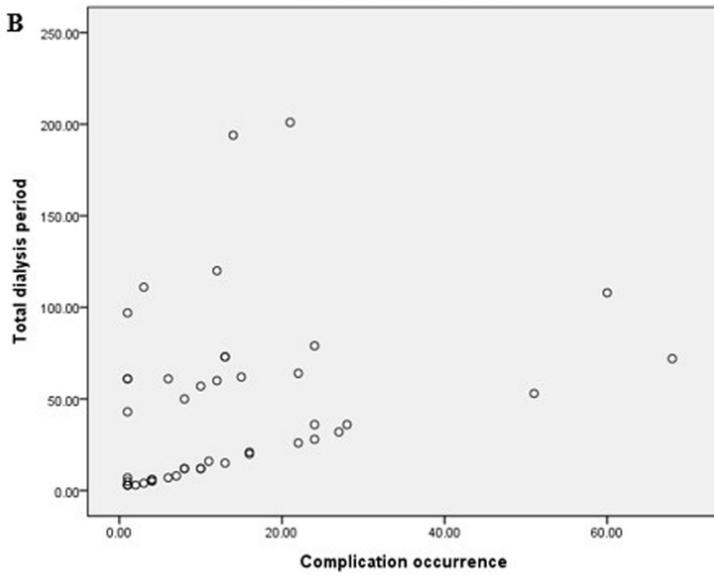
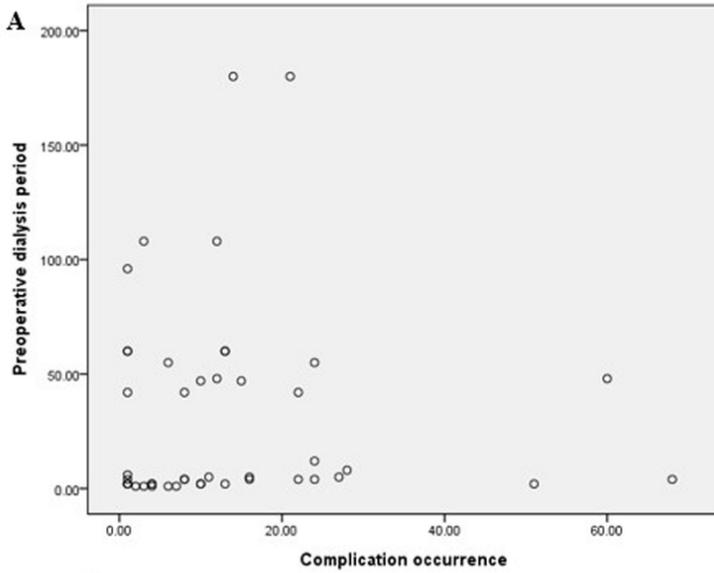
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## Figures



**Figure 1**

Serial radiographs of a 71-year-old total hip arthroplasty patient. (A) Left femoral neck fracture. (B) Postoperative day 14, C-reactive protein level and wound complications. (C) A change in the acetabular cup angle at 7 months postoperation.



**Figure 2**

Scatter Plots. (A) No statistically significant relationship between preoperative dialysis duration and occurrence of complications ( $r = 0.184$ ,  $P = 0.227$ ). (B) Significant correlation between total dialysis duration and occurrence of complications ( $r = 0.477$ ,  $P = 0.001$ ).