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Results of Hip Arthroplasty Using a COREN Stem at a Minimum of Ten Years

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Purpose: We report on the 10-year clinical hip function and radiologic outcomes of patients who underwent hip arthroplasty using a COREN stem.
Materials and Methods: A consecutive series of 224 primary cementless hip arthroplasty implantations were performed using a COREN stem between 2009 and 2011; among these, evaluation of 128 hips was performed during a minimum follow-up period of 10 years. The mean age of patients was 65.4 years (range, 40-82 years) and the mean duration of follow-up was 10.8 years (range, 10-12 years). Evaluation of clinical hip function and radiologic implant outcomes was performed according to clinical score, thigh pain, and radiologic analysis.
Results: Dramatic improvement of the mean Harris hip score (HHS) from 59.4 preoperatively to 93.5 was observed at the final follow-up ($P \leq 0.01$). Stable fixation was demonstrated for all implants with no change in position except for one case of Vancouver type B2 periprosthetic femur fracture. A radiolucent line (RLL) was observed in 16 hips (12.5%). Thigh pain was observed in only two hips (1.6%) at the final follow-up. There were no cases of osteolysis around the stem. The survival rate for the COREN stem was 97.7%.
Conclusion: Good long-term survival with excellent clinical and radiological outcomes can be achieved using the COREN femoral stem regardless of Dorr type.

Key Words: Hip, Femur, Hip replacement arthroplasty, Prosthesis

INTRODUCTION

Hip arthroplasty is regarded as the most successful surgical technique utilized in the field of orthopedics. A biologic cementless stem was recently developed in an effort to improve the performance of the stem[1]. According to findings reported in recent studies[2-6], improved clinical and radiological outcomes were achieved with use of cementless stems with rectangular tapering compared with cemented stems.

The COREN stem (Corentec, Seoul, Korea), a cementless, tapered stem with a rectangular shape, was developed and authorized in Korea in the early 2000s. According to the findings of a previous study reported by Park et al.[7], there were no cases of implant loosening or osteolysis, and no cases requiring revision surgery after using the COREN stem during a follow-up period of 3.2 years. During a follow-up period of seven years with the same patient groups, excellent survival rates as well as excellent outcomes were achieved both clinically and radiologically with use of the COREN stem[8]. However, to the best of our knowledge, no

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study regarding the long-term clinical and radiological outcomes with use of the COREN stem has been reported.

The purpose of this study was to evaluate the clinical hip function and radiologic implant outcomes of patients who underwent hip arthroplasty using the COREN stem during a follow-up period of at least 10 years.

MATERIALS AND METHODS

The protocol for this study was approved by the Institutional Review Board (IRB) of Inha University Hospital (IRB No. INHAUH 2022-06-007). Due to its retrospective nature, exemption from informed consent was obtained from the IRB of Inha University Hospital.

1. Patients

A consecutive series of 224 primary, cementless hip arthroplasty procedures were performed using the COREN stem from June 2009 to December 2011 at our hospital. Among these cases, evaluation of 124 patients (128 hips) was performed during a minimum follow-up period of 10 years. The study included 65 males (67 hips) and 59 females (61 hips) with a mean age of 65.4 years (range, 40-82 years). The preoperative diagnosis included 24 cases of fracture, 64 cases of avascular necrosis, and 40 cases of osteoarthritis. Total hip arthroplasty was performed in 98 hips with ceramic-on-ceramic bearing (Biolox® Forte alumina; CeramTec, Plochingen, Germany). Bipolar hemiarthroplasty was performed in 30 hips with ceramic (Biolox® Forte alumina). All surgical procedures were performed by a senior surgeon (J.S.K.) with the patient placed in lateral position using the posterolateral approach. The mean duration of follow-up was 10.8 years (range, 10-12 years) (Table 1).

Table 1. The Patients' Preoperative Characteristics Data

Characteristic	Value
Age at surgery (yr)	65.4±6.5 (40-82)
Sex	
Female	59 (61 hips, 47.7%)
Male	65 (67 hips, 52.3%)
Arthroplasty	
Total hip arthroplasty	98 (76.6)
Bipolar hemiarthroplasty	30 (23.4)
Preoperative diagnosis	
Fracture	24 (18.8)
Avascular necrosis	64 (50.0)
Osteoarthritis	40 (31.3)

Values are presented as mean±standard deviation (range) or number (%).

2. Used Stem

The COREN stem (BENCOX®), consisting of titanium alloy (Ti6Al4V; 6% aluminum and 4% vanadium), has a straight, tapered, double wedged stem with a rectangular shape. It has a grit blasted surface with a roughness of 5.5 ㎛, which is treated by micro-arc oxidation, providing the advantage of biocompatibility. Three vertical ribs are located on the proximal portion of the stem; anterior, posterior, and lateral (Fig. 1)[7-10]. These structural characteristics enable more precise anatomical fitting of the stem to the proximal femur with better biocompatibility. The COREN stems was used in all cases except for some cases involving severe dysplastic hips with Dorr type C.

3. Clinical Outcome Assessment

The patients presented to the outpatient clinic at postoperative six weeks, six months, one year, and then annually. Evaluation of clinical performances was performed using the Harris hip score (HHS) questionnaire at the follow-up visit[11]. For evaluation of thigh pain, hip physicians focused on pain that started around the thigh and ambulatory pain. Patients' charts were reviewed at postoperative and final follow-up for estimation of thigh pain and complications. Judgment regarding the cause of pain was made by the senior author with comprehensive consideration of pain,

Fig. 1. Photograph of COREN stem (BENCOX®; Corentec, Seoul, Korea). The stem has three vertical ribs on proximal portion; anterior, posterior, and lateral.

type, location, frequency, radiolucent line (RLL) around the stem, and spinal stenosis.

4. Radiological Outcome Assessment

Review of radiographs was performed by two independent observers (D.J.R. and Y.C.N.) who were not involved in the operation. Evaluation and classification of preoperative femoral geometry was performed using radiographs according to Dorr type[12]. Evaluation of postoperative osteolysis, RLL, stress shielding, component migration, and loosening was performed using serial radiographs[13]. Osteolysis was defined as focal bony changes such as cystic lesions, which were recorded at the time they were first detected during follow-up[14]. Radiographs were checked thoroughly for detection of either RLL or stress shielding at every follow up visit. Measurement for the presence of RLL was performed in accordance with Gruen criteria[14]. Review of stress shielding at the bone-implant was performed according to Engh's classification[13]. Migration and subsidence of the component were determined according to preoperative and postoperative changes in distance from the inferior margin of the stem to the superior margin of the greater trochanter[15,16]. Loosening was defined as either complete RLL or subsidence over 5 mm[17].

5. Statistical Analysis

A paired *t*-test analysis was performed for evaluation of differences between preoperative and postoperative HHS. The ANOVA test was performed in order to determine the results for Dorr-type groups for analysis of the affect according to the femoral geometry. IBM SPSS Statistics for Windows (ver. 25.0; IBM, Armonk, NY, USA) was used in performance of the analysis, and *P*-values <0.05 were considered statistically significant. Kaplan–Meier survival was used for determination of survival rates, which were defined as any reoperation at the endpoint. For analysis of the power of the prior sample size, 111 samples are required for detection of an effect size of 0.3 (power=80%, two-sided α=0.05, correlation between repeated measures=0.1, and non-spherical correction ε=0.25).

RESULTS

1. Clinical Outcome

Dramatic improvement of the mean HHS from 59.4 preoperatively to 93.5 was observed at the final follow-up ($P \leq 0.01$) (Table 2). No variation of the difference in preoperative and postoperative HHS was observed between Dorr types. Occasional activity-related thigh pain was reported in two hips (1.6%) belonging to Dorr type A and type C. Relief from thigh pain within two years from the operation was reported in all patients.

2. Radiological Outcome

Evaluation and classification of femoral geometry was performed preoperatively according to the Dorr classification (type A, 76 hips; type B, 44 hips; type C, 8 hips) (Table 2). An RLL located around the femoral stem was observed in 16 hips (12.5%), Gruen zones 1, 2, and 7. These lines appeared within one year (range, 3-12 months) after the operation and then remained unchanged with the sclerotic outer margin (Fig. 2). RLL was observed in various Dorr type 3 groups: 11 in type A (14.5%), four in type B (9.1%), and one in type C (12.5%). No significant difference was observed among Dorr groups (*P*=0.232).

Stress-shielding was observed in 51 cases, and no signif-

Table 2. Clinical and Radiological Results between Dorr Types

Parameter	Dorr proximal femoral types			*P*-value
	A (n=76)	B (n=44)	C (n=8)	
Clinical outcome				
Pre HHS	60.1	58.6	57.6	0.135
Post HHS	93.7	93.1	93.2	0.240
Thigh pain	1 (1.3)	0	1 (12.5)	0.125
Radiological outcome				
Radiolucent line	11 (14.5)	4 (9.1)	1 (12.5)	0.232
Stress shielding	34 (44.7)	15 (34.1)	2 (25.0)	0.135

Values are presented as mean only or number (%).
HHS: Harris hip score.

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icant difference was observed among the three Dorr type groups: 34 in type A (44.7%), 15 in type B (34.1%), and two in type C (25.0%) (*P*=0.135) (Fig. 3). There were no cases involving changes in implant position, including stem subsidence, stem loosening, and osteolysis, until the final follow-up radiograph (Fig. 4).

3. Complications

Posterior hip dislocation was detected in two hips, for

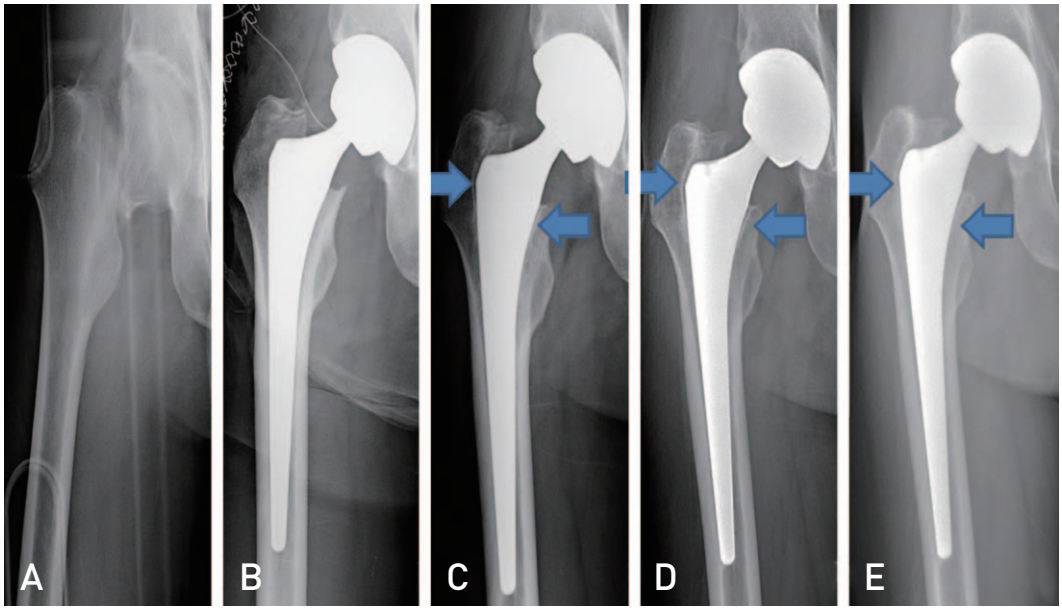

Fig. 2. (**A**) Preoperative radiography of a 73-year-old male patient suffered from femur neck fracture. (**B**) Immediate postoperative radiography after total hip arthroplasty shows a well-implanted prosthesis. (**C**) Anteroposterior radiography shows stably fixed implants with a radiolucent line in Gruen zone 1, 2, and 7 at 1 year after arthroplasty. (**D**) Anteroposterior radiography taken 5 years after arthroplasty demonstrates no marked changes with radiolucent lines that had not progressed. (**E**) Anteroposterior radiography taken 10 years after arthroplasty demonstrates no marked changes with radiolucent lines that had not progressed, and stable bony fixation of both the acetabular cup and femoral stem.

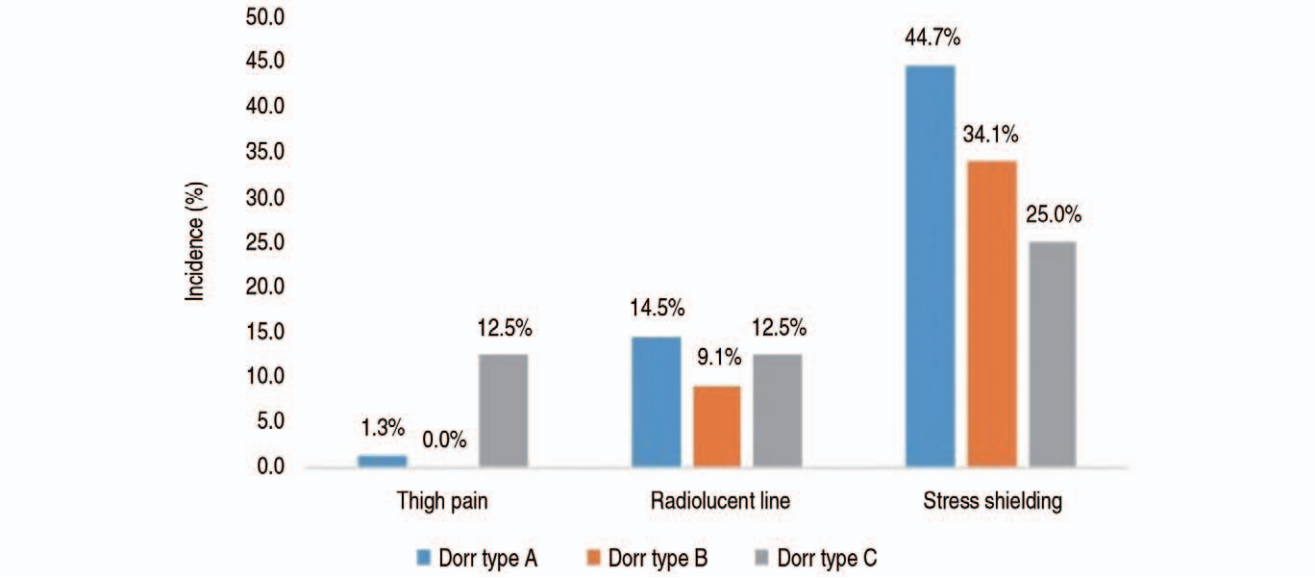

Fig. 3. Incidence of thigh pain, stress shielding, and radiolucent lines (thigh pain, *P*=0.125; radiolucent line, *P*=0.232; stress shielding, *P*=0.135).

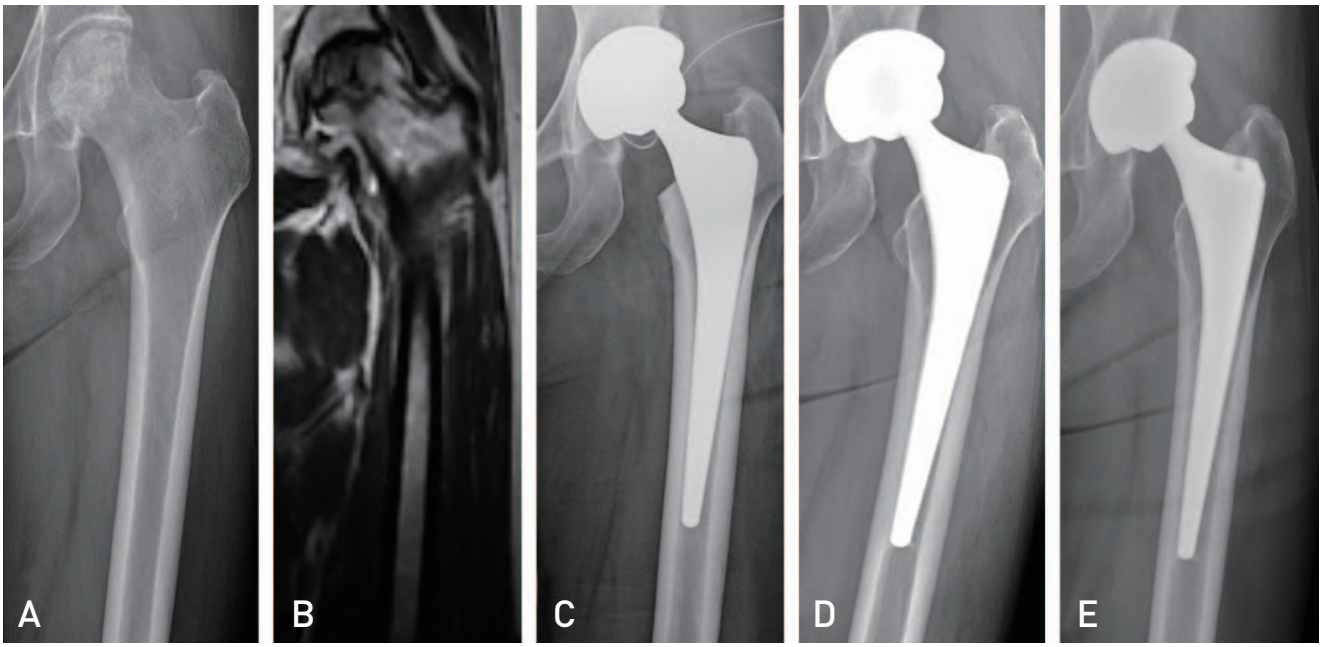

Fig. 4. (**A**) Preoperative radiography of a 56-year-old female patient suffered from avascular necrosis of left femoral head. (**B**) Preoperative magnetic resonance imaging (T2-weighted image) of a same female shows avascular necrosis of left femoral head. (**C**) Anteroposterior radiography taken at 1 year after arthroplasty shows well-fixed implants without a radiolucent line. (**D**) Anteroposterior radiography taken at 5 year after arthroplasty demonstrates stably well-fixed implants without a radiolucent line. (**E**) Anteroposterior radiography taken 11 years after arthroplasty with well-fixed stem, no radiolucent lines, and mild stress shielding on Gruen zone 1.

which conservative treatment was administered after manual reduction and application of the brace. No sciatic or femoral nerve palsy was observed during the follow-up period. Two cases with deep tissue infection underwent stem revision.

A periprosthetic femur fracture (Vancouver type B2) caused by a slip down event occurred in one case (0.8%) two years after the initial hip arthroplasty procedure (Fig. 5). Stem exchange and cerclage wiring were performed for treatment of the fracture. Good union status without complications was demonstrated on radiography performed 10 years after revision surgery.

4. Survival Analysis

Stable fixation was demonstrated in all hips except for one case due to a periprosthetic fracture and two cases due to deep infection. The Kaplan–Meier survival rate for the COREN stem was 97.7% (Fig. 6).

DISCUSSION

In this study, a satisfactory survival rate of 97.7% was demonstrated for the COREN stem with long-term follow-up period of at least 10 years. Regarding clinical outcomes, HHS showed considerable improvement from 59.4 to 93.5, and only two patients reported thigh pain, and relief was achieved during the follow-up period. Results regarding radiological outcomes showed that there were no changes of implant position including stem subsidence, stem loosening, and osteolysis.

A C2 stem (Lima Corporate SpA, Udine, Italy) was used in our previous study; the results showed more frequent occurrence of RLL and thigh pain in patients with Dorr type A[18]. The design of the C2 stem is similar to that of the COREN stem; a rectangular tapered stem with proximal fitting. Unlike the C2 stem, the COREN stem has three vertical ribs located on its proximal portion. The presence of three proximal vertical ribs can have an effect on rotational stability and improvement of early fixation can be achieved. In this study using the COREN stem, the RLL and thigh incidences did not show correlation with femoral geometry did not show correlation with femoral geometry; Dorr type. RLL was observed in 16 cases (12.5%, Gruen zones 1, 2, and 7); however, it remained unchanged with the sclerotic outer margin until the final follow up, and a good survival rate (97.7%) was obtained. These results are meaningful in that good longevity can be achieved regard-

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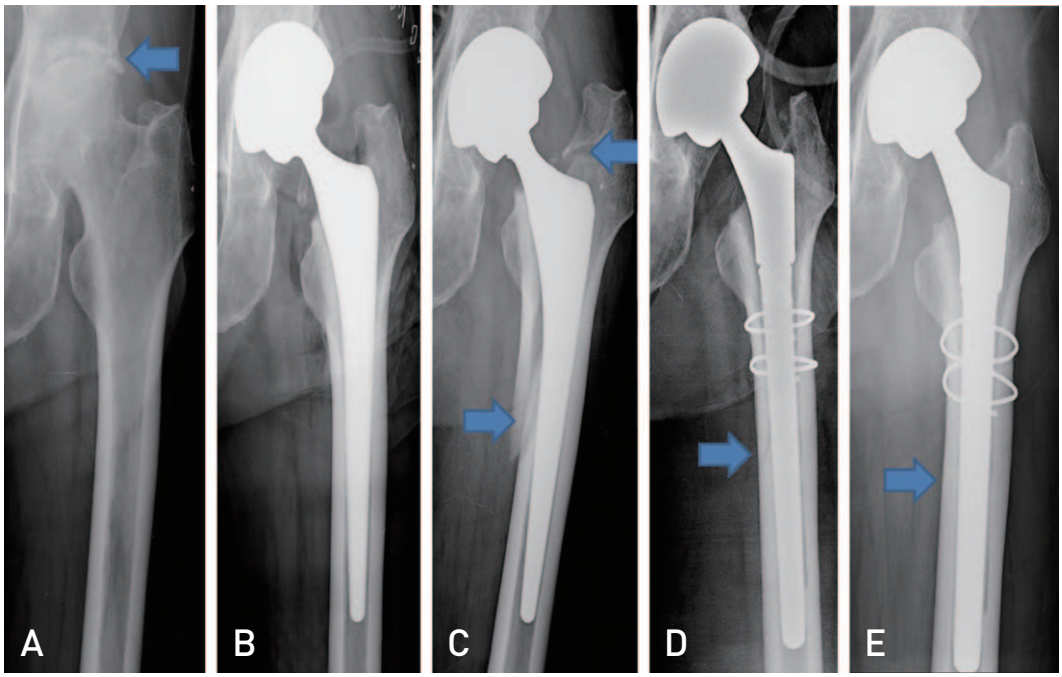

Fig. 5. (**A**) Preoperative radiography of a 60-year-old male suffered from avascular necrosis of the femoral head. (**B**) Immediate postoperative radiography after total hip arthroplasty shows a well-implanted prosthesis. (**C**) A radiography at two years after surgery shows periprosthetic fracture (Vancouver type B2) was seen at proximal femur. (**D**) Immediate postoperative radiography after revision surgery shows a stable implant fixation. (**E**) Anteroposterior radiography taken 10 years after revision surgery demonstrates well healed previous fracture without any complications.

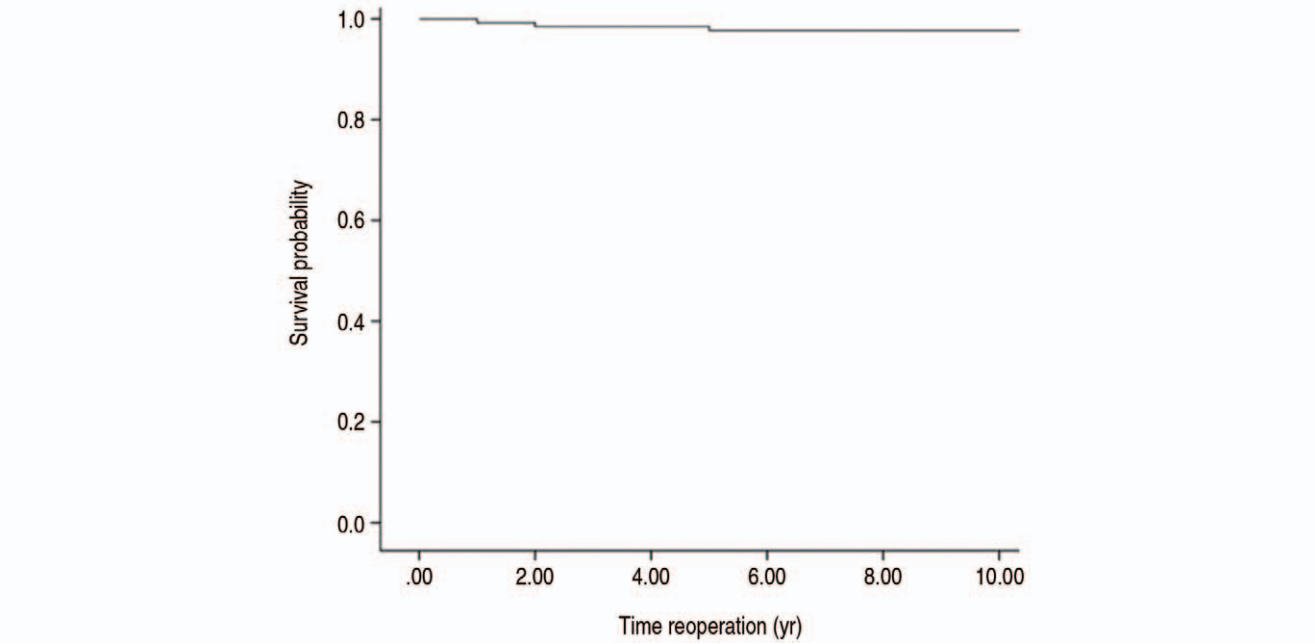

Fig. 6. Ten-year Kaplan–Meier survival curves using any reoperation at the end point.

less of femoral geometry using the COREN stem.

Variation of the reported incidence of thigh pain after hip arthroplasty using a cementless stem did not show correlation with femoral geometry from 0% to 20% has been reported[8,10,19,20]. Commonly cited hypotheses for the cause of thigh pain include reaming of the distal canal and stress

transfer due to a tight fit[21,22]. In our studies, activity-related thigh pain was reported by two patients. Similar to the result for RLL, no variation in the incidence of thigh pain was observed according to femoral geometry. In this study, relief of thigh pain was achieved within two years after surgery without complications in all patients. Although the cause of the pain relief may be uncertain, previous studies reported that relief of thigh pain was achieved with time[8,18].

In this study, stress shielding was observed in 51 cases (39.8%); these results differ from those reported in previous studies[5,8]. Kim et al.[8] reported stress shielding in only 19.7% of cases; however, Kim et al.[5] reported 80.3% of cases. Subjective interpretation in evaluation of radiographs might be the primary reason for these discrepancies.

In the current study, satisfactory stability was demonstrated for all stems without change of position and a good survival rate (97.7%) was obtained. The survival rate for the COREN stem was comparable with that of other cementless stems. A survival rate of 92% was reported for the cementless Spotorno stem (CLS stem; Zimmer, Warsaw, IN, USA) after a follow-up period of 10 years in patients of all ages[23]. Similarly, the result from 10-year follow-up of the Zweymuller stem (Allopro, Berne, Switzerland) showed an overall survival rate of 99%[24]. Compared with cemented stems, an all-cause survival rate of 94.7% was reported for the Exeter Universal cemented stem (Stryker Orthopedics, Mahwah, NJ, USA) in active patients under 50 years[25]. According to the NICE guideline (National Institute for Clinical Excellence) "good" is defined as a revision rate of 10% or less at 10 years of follow-up[8,26]. According to this standard, a "Good" survival rate was demonstrated for the COREN stem with results that were similar to those for other previously used stems.

Our study included only one case (0.8%) of periprosthetic femur fracture (Vancouver type B2), which occurred after a slip-down event at two years follow up; however, our focus should be on stem loosening along with periprosthetic fracture. As reported by Lim et al.[27], a higher risk of stem loosening with periprosthetic femur fracture was observed with hip arthroplasty using cementless, grit-blasted tapered stems compared with hip arthroplasty using porous-coated stems. Previous studies have reported that the tapered wedge design and rectangular cross-sectional shape can contribute to stress concentration at certain points[19,20,27]. In addition, grit-blasted surfaces provide a bony on-growth environment that might not withstand shearing forces, compared with bony ingrowth[22].

Lack of a control group is a limitation of this study. In addition, patients with loss of follow-up could not be considered due to the retrospective design of the study. Another limitation is that demographic factors such as differences in total hip arthroplasty and bipolar hemiarthroplasty are not considered. Another limitation of this study is the relatively low follow-up rate (128/224, 57.1%). Because of demographic factors, the overall follow-up rate has decreased due to the difficulty in conduct of long-term follow-up in elderly patients. However, our findings have some merits; more than 120 cases with a follow-up period of 10 years were sufficient for statistical analysis or evaluation of long-term survival rates. Our results can provide readers with valuable data regarding the long-term stability of the COREN stem.

CONCLUSION

Good long-term survival with excellent clinical and radiological results can be achieved using the COREN femoral stem regardless of Dorr type.

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CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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