



Cementless total hip arthroplasty following failed internal fixation for femoral neck and intertrochanteric fractures: A comparative study with 3–13 years' follow-up of 96 consecutive patients

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ABSTRACT

Background: The aim of this study was to investigate the postoperative outcomes of cementless Total hip arthroplasty (THA) following failed internal fixation for femoral neck and intertrochanteric fractures.

Method: Ninety-six cementless THAs for failed internal fixation after femoral neck fracture (59, group I) and intertrochanteric fracture (37, group II) with a minimum follow-up of 3 years were analyzed. Clinical and radiologic evaluations were performed on all patients.

Results: The intraoperative blood loss and operating time were significantly increased in group II ($p = 0.001$, $p = 0.001$, respectively). Harris hip score at last follow-up was significantly improved in group I ($p = 0.007$) but, there were no differences in hospital stay, Koval score at last follow-up, and perioperative complications between both groups. Long femoral stems for diaphyseal fitting were frequently used in group II (32/37, 86%) ($p = 0.001$). Radiographically, none of the acetabular cups showed evidence of migration, loosening. All cases showed stable fixation of the femoral stem at last follow-up.

Conclusions: Outcomes of cementless THA following failed internal fixation for femoral neck and intertrochanteric fractures were satisfactory; increased intraoperative blood loss, operating time, and requirement of long femoral stem should be considered in the latter type of fracture.

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Introduction

Proximal femoral fractures, one of the most common fragility fractures associated with osteoporosis, are becoming more prevalent as the population age [1]. The approximate incidence of proximal femoral fractures is more than 28,000 per year in the Korean population [2], and is growing rapidly. Femoral neck and intertrochanteric fractures account for most of these fractures. Although primary surgical procedures differ for these common two fractures, the salvage procedures for failed internal fixation often includes conversion to total hip arthroplasty (THA).

The treatment of femoral neck fractures has traditionally included either internal fixation with cannulated screws or acute

arthroplasty in the form of hemiarthroplasty or THA. Despite the increased use of arthroplasty, internal fixation of nondisplaced and displaced fractures in young patients remains a frequently successful option [3]. There have been many advances in internal fixation techniques to deal with poor bone quality and severely comminuted intertrochanteric fractures so as to allow early ambulation [4]. Internal fixation is the treatment of choice for most intertrochanteric fractures; however, internal fixation for proximal femoral fractures is frequently associated non-union, loss of fixation, femoral head necrosis, posttraumatic arthritis, or symptomatic hardware [4,5]. Although appropriate internal fixation enables most patients to resume activities of daily living without complications, failed internal fixation or non-union leads to reduced physical activity. Failed internal fixation after proximal femoral fractures, especially in older patients, are surgically challenges with limited options [6]. Several technical issues have been associated with the conversion of these fractures into THA, such as removal of implants, anatomical bony deformity, bone defect, poor bone quality, and associated trochanteric nonunion [7,8]. These issues increase the rate of postoperative complications

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such as periprosthetic fractures, hip dislocations, and infections compared with primary THA [9]. Failed intertrochanteric fractures are expected to be more deformed and difficult to operate than failed femoral neck fractures, which thus affects the results. However, the comparative results of THA between these fractures are still limited.

The aim of this retrospective study was to investigate the postoperative outcomes of cementless THA following failed internal fixation for proximal femoral fractures, and to compare patients with failed femoral neck fractures and intertrochanteric fractures. We hypothesize that the more complex the surgery, the higher the incidence of complications, and the worse the outcome.

Materials and methods

Patient information was reviewed by the university human subjects committee, and Institutional Review Board approval was obtained prior to commencing the study. A retrospective cohort study analyzed a consecutive series of 96 cementless THAs for failed internal fixation after femoral neck and intertrochanteric fractures at our institution between January 2005 and May 2015. The exclusion criteria were: pathologic fracture, infection, neoplasia, and contralateral hip fracture. We also excluded patients who were performed by conversion to bipolar hemiarthroplasty.

Patients included 45 men (45 hips) and 51 women (51 hips). The mean age at the time of THA was 64.1 years (range, 30–90 years). The mean time interval from internal fixation to THA conversion was 10.2 months (range, 4–18 months), and the mean follow-up period was 6.3 years (range, 3–13 years). Fifty-nine patients previously underwent internal fixation for femoral neck fractures (group I), and 37 patients underwent internal fixation for intertrochanteric fractures (group II). There was no significant difference in demographic parameters in terms of sex, body mass index, bone mineral density, or the American Society of

Anesthesiology score between both groups, except for age at hip arthroplasty. Patient demographics are summarized in Table 1.

Operative methods

We performed meticulous preoperative templating and planning in all patients, including the determination of cutting level of the femoral neck, size of the implant, and optimal site of cortical fixation. All operations were performed using a posterolateral approach with enhanced soft tissue repair, with patients in the lateral decubitus position [10]. Once the joint was opened, we routinely performed synovial fluid analysis and bacteriologic testing, and frozen sections were used to confirm the absence of acute infection. Hip dislocation was performed before removal of the previously inserted implant for internal fixation to prevent femoral fracture. Following hip reduction, fixation devices were removed and the femoral head was cut. For acetabular component fixation, a 1–2 mm press-fit fixation technique, with or without screw fixation was performed [11,12]. As previous intertrochanteric fracture and surgery can lead to distortion of the proximal femoral anatomy, medullary canal obstruction, and stress-riser formation, the femoral canal was reamed under fluoroscopic image intensifier. After adequate femoral canal preparation by graduated reaming using rasps, the final size of the component was determined when a properly lateralized broach made contact with the cortical bone in the calcar region or distal diaphyseal part of the femur. The joint was reduced, and the stability and soft tissue tension of the hip were assessed. After the insertion of cementless stem, if necessary, the trochanteric and medial fragments were reduced and reconstructed with the help of cerclage wire (Fig. 1). Hemostasis was achieved and short external rotators were reinserted transosseously.

Postoperatively, all patients were prescribed low molecular weight heparin as thromboprophylaxis. Patients were instructed to

Table 1
Patient demographics and preoperative characteristics.

	Total	Group I	Group II	p-value
No. (hips)	96	59	37	
Men/Women	45/51	29/30	16/21	0.251
Age at hip arthroplasty (year)	64.1 ± 14.6	61.2 ± 13.1	69.1 ± 14.2	0.007
BMI (kg/m ²)	22.8 ± 3.7	22.4 ± 3.5	23.5 ± 2.8	0.142
BMD (T-score)	-1.92 ± 0.32	-1.83 ± 0.31	-2.01 ± 0.43	0.282
ASA score				
1/2	30	20	10	0.590
3/4	66	39	27	0.641
Follow-up duration (year)	6.3 ± 4.5	6.5 ± 4.3	6.1 ± 3.9	0.743
Cause for THA				
Cutout	39	20	19	0.072
Nonunion	28	13	15	0.001
Femoral head necrosis	23	22	1	0.001
Posttraumatic osteoarthritis	6	4	2	0.787
Comorbidities				
Hypertension	33	14	19	0.006
Diabetes	22	9	13	0.024
Cerebrovascular accident	5	2	3	0.311
Cardiovascular disease	8	4	4	0.487
Venous thromboembolism	4	1	3	0.126
Pulmonary disease	7	4	3	0.808
Chronic kidney disease	9	6	3	0.736
Fixation used (failure of fixation)				
Intramedullary nail	29	4	25	
Dynamic hip screw	10	1	9	
Cannulated screw	51	51	0	
Anatomic plate	3	0	3	

Data displayed using means ± SD or n; group I represents THAs for failed internal fixation after femoral neck fracture while group II represents THAs for failed internal fixation after femoral intertrochanteric fracture.

BMI = body mass index, BMD = bone mineral density, ASA = American Society of Anesthesiologist physical status classification.

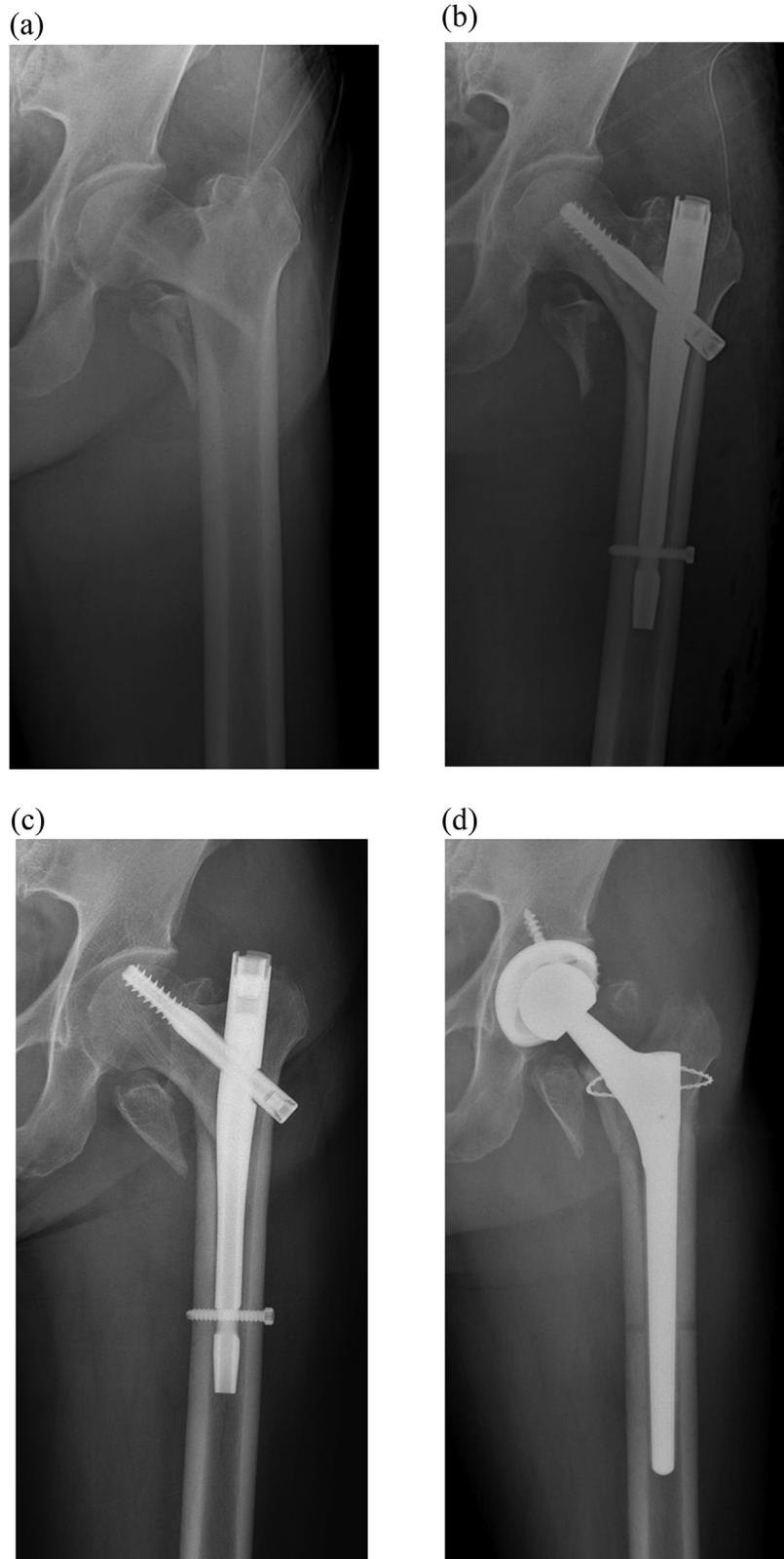


Fig. 1. Anteroposterior radiograph of a 74-year-old female showing a left femoral intertrochanteric fracture treated with internal fixation (A and B). Non-union results in the loss of reduction and cutout of lag screw (C). Anteroposterior radiograph showing revision of failed internal fixation with cementless total hip arthroplasty with long femoral stem and reconstruction of medial fragments with the help of circlage wire (D).

walk with partial weight-bearing with the aid of crutches or walker on the second day, with full weight-bearing as tolerated.

Implant description

Cementless implants were used in all patients in both groups. A single type of acetabular component (Trilogy, Zimmer, Warsaw, Indiana) and highly cross-linked polyethylene liner (Longevity, Zimmer) were used in all procedures. Alumina ceramic head (BioloX forte, CeramTec AG, Plochingen, Germany) and Delta ceramic head (BioloX delta, CeramTec) were used for prosthetic femoral head. All ceramic heads were coupled with highly cross-linked polyethylene liners. The Fiber Metal Taper stem (Versys, Zimmer), Wagner SL stem (Zimmer), and Beaded FullCoat stem (Versys, Zimmer) were used in 63, 28, and 5 hips, respectively. The decision to select femoral prosthesis was made based on preoperative templating and the condition of the proximal femur at the time of surgery. We should use a stem that can achieve bypass fixation below the most distal cortical defect if possible. To achieve distal fixation is often necessary to use a revision type stem with fully porous coated design.

Clinical and radiologic evaluation

The duration of hospital stay, intraoperative blood loss, operating time based on anesthesia record, perioperative complications, 1-year mortality, and reoperation on any reason were recorded. Patients were followed up at 6 weeks, 3 months, 6 months, 12 months, and annually thereafter from surgery. The Harris hip score (HHS) and Koval score were used to assess functional outcomes.

All patients underwent preoperative computed tomography (CT) scans of the pelvis and the entire femur. All CT examinations were performed with the patient in the supine position. Multi-detector CT with 128 detector rows was used with 2.0 mm slice thickness. Femoral neck anteversion, defined as the angle between the neck axis and posterior condylar axis, was measured on axial CT images [13]. Plain radiographs were obtained at each visit. For calibration, a radiopaque bar 10-cm in length was attached to the inner aspect of the thigh, as near as possible to the pelvis. Standardized antero-posterior (AP) radiographs of both hips, which present controlled rotation and tilt, were used to measure the radiologic parameters. By measuring the distance from the inter-teardrop line to the uppermost point of the lesser trochanters of the femur, we determined that difference as a degree of leg length discrepancy (LLD) [14]. LLD was expressed as a negative value for shorter than the contralateral side and a positive value for longer. The inclination of acetabular component was measured on the basis of the inter-tear drop line [15], and the anteversion was

measured on AP radiograph using Liaw et al's method [16]. Changes in the inclination $>5^\circ$ and vertical or horizontal migration of the acetabular component ≥ 2 mm were defined as acetabular component loosening [17]. The stability of femoral component was classified into stable bone ingrowth, stable fibrous ingrowth, and unstable prosthesis at the last follow-up radiographs [18]. Subsidence of the femoral component was measured using the distance from the greater trochanter to the junction of the neck and lateral border of the implant [19]. The following findings were considered as femoral component loosening: a radiolucent line >1 mm throughout the Gruen zones, changes in $\geq 3^\circ$ of valgus and varus alignment, and stem subsidence ≥ 2 mm [17].

Statistical analysis

Summary data were described with mean and standard deviation for continuous variables and number for categorical ones. Continuous variables were analyzed using the *t*-test (or Mann-Whitney U test where appropriate) for two independent samples to compare the results of both groups. The chi-square test (or Fisher's exact test where appropriate) was used for analyses of categorical data. Significant difference was considered present with a two-sided *p*-value less than 0.05. Statistical analysis was performed using SPSS software, version 20.0 (SPSS Inc., Chicago, Illinois, USA)

Results

Of the 59 THAs in group I, 51 were treated with cannulated screws, 4 with proximal femoral nail, and 1 with dynamic hip screw. Of the 27 THAs in group II, 25 were treated with proximal femoral nail, 9 with dynamic hip screw, and 3 with anatomic plate. The most common indication for secondary THA was a cutout in 39 patients, followed by non-union in 28 patients, femoral head necrosis in 23 patients, and posttraumatic osteoarthritis in 6 patients. Non-union was more frequent in group II, compared to femoral head osteonecrosis in group I ($p=0.001$, $p=0.001$, respectively).

Clinical outcomes

The mean intraoperative blood loss was 637.4 mL, and the mean operating time was 156.4 min (Table 2). Intraoperative operative blood loss was greater ($p=0.001$), and operating time was longer ($p=0.001$) in group II than in group I. All patients demonstrated clinically significant pain relief and return to ambulation after the operation. Both groups showed good or excellent HHS at an average of 6.3 years (range, 3–13 years). However, there was a statistically significant improvement in HHS between both groups

Table 2
Comparison of clinical outcomes during perioperative period between groups.

	Total	Group I	Group II	<i>p</i> -value
Hospital stay (day)	16.44 ± 5.52	15.38 ± 5.40	17.97 ± 7.12	0.104
Intraoperative blood loss (mL)	637.4 ± 130.8	535.2 ± 121.5	786.5 ± 171.9	0.001
Operating time (minute)	156.4 ± 42.6	128.4 ± 26.1	195.5 ± 59.2	0.001
Harris hip score at last follow-up				
Preoperative	41.2 ± 5.2	42.1 ± 4.1	40.3 ± 5.2	0.161
At last follow-up	94.2 ± 9.2	96.7 ± 9.1	89.1 ± 10.4	0.007
Koval score at last follow-up	2.5 ± 1.8	2.7 ± 1.8	2.2 ± 1.9	0.388
Perioperative complications				
Dislocation	7	4	3	0.737
Operative site infection	0	0	0	
Death within 1 year after surgery	7	4	3	0.808
Reoperation on any reason	0	0	0	

Data displayed using means ± SD or n; group I represents THAs for failed internal fixation after femoral neck fracture while group II represents THAs for failed internal fixation after femoral intertrochanteric fracture.

at the last follow-up ($p=0.007$). There were no significant differences in the duration of hospital stay and Koval score at the last follow-up between both groups. There were four dislocations in 4 patients were observed after conversion of a prior femoral neck fracture and three dislocations in 3 patients after conversion of a prior femoral intertrochanteric fracture. There were no significant differences in perioperative complications and 1-year mortality after surgery between both groups. No patient in both groups experienced postoperative periprosthetic joint infection or reoperation for any reason till the last follow-up.

Surgical and radiologic outcomes

The mean preoperative femoral neck anteversion on the affected side was 15.1° in group I and 7.0° in group II ($p=0.030$). Preoperative femoral neck anteversion of the affected side was 7° less than that on the healthy side in group II (Table 3) (Fig. 2). There were no differences in femoral neck anteversion on the healthy side between both groups. The mean postoperative LLD was -0.8 mm in group II, which was significantly shorter than group I ($p=0.006$).

The acetabular cup position and size were similar between both groups. None of the acetabular cup demonstrated evidence of migration or loosening at the time of last follow-up. The femoral stems used in group I consisted of 58 cases of Fiber Metal Taper stem and 1 case of Wagner SL stem, whereas 5 cases of Fiber Metal Taper stem, 27 cases of Wagner SL stem, and 5 cases of Beaded FullCoat stem were seen in group II. Long femoral stems for diaphyseal fitting were frequently used in group II (32/37, 86%) ($p=0.001$). The mean size of prosthetic ceramic head was 30.9 mm, and there were no differences between the groups. The mean size of femoral stem was larger in group II than in group I ($p=0.000$). All femoral stems demonstrated stable fixation, with 78 cases with bony ingrowth and 18 cases with stable fibrous ingrowth, at the last follow-up; there were no differences between both groups. An average of 2.7 mm of subsidence occurred within first 3 weeks post-surgery in 8 femoral stems, and there was no progressive

subsidence. There was no progressive osteolysis and loosening around the femoral stem at the last follow-up.

Discussion

Most retrospective studies have investigated proximal femoral fractures in a comprehensive manner. These studies reported a short follow-up result of 2 years after surgery and were compared according to the implants used for internal fixation [20,21]. Consequently, previous studies had substantial differences compared with our study in terms of the inclusion criteria and the parameters investigated. The present study investigated cementless THA performed following failed internal fixation for femoral neck and intertrochanteric fractures with 3–13 years' follow-up of 96 consecutive patients. Cementless THA can serve as a good salvage option for the restoration of normal life in this group of patients. The strength of this study lies in the high number of THA conversions with relatively long-term follow-up periods.

The management of failed femoral neck and intertrochanteric fractures is challenging. A variety of treatment options include revision internal fixation with or without bone grafting and conversion to hip arthroplasty. Hip arthroplasty offers the advantage of early weight-bearing and mobilization. Although the choice of implant - whether THA or hemiarthroplasty - will depend upon the age of the patient, activity level, and comorbidities, patients with acetabular damage due to implant penetration or femoral head necrosis underwent THA. Several studies have reported good to excellent results for conversion hip arthroplasty with the use of cemented prosthesis [5,22]. However, extravasation of cement through screw holes and fracture lines is inevitable, which may lead to suboptimal pressurization of cement and poor remodeling of the cortical bone, as well as higher risk of trochanteric non-union or postoperative periprosthetic fracture [23,24]. Moreover, there might be a cement-related cardiovascular event in elderly patients [25]. Due to the limitations of cemented fixation, cementless THA seems to be more fascinating in this situation.

Table 3
Comparison of radiologic outcomes during perioperative period between groups.

	Total	Group I	Group II	p-value
Preoperative femoral neck anteversion ($^\circ$)				
Affected side	13.3 ± 7.4	15.1 ± 4.2	7.0 ± 8.3	0.030
Healthy side	14.4 ± 4.4	14.6 ± 4.3	14.0 ± 4.4	0.656
Postoperative LLD (mm)	0.3 ± 2.7	1.0 ± 1.5	-0.8 ± 2.8	0.006
Acetabular component				
Trilogy [®] (Zimmer, Warsaw, IN)	96	59	37	
Cup inclination ($^\circ$)	44.6 ± 2.8	45.1 ± 1.0	43.4 ± 2.9	0.203
Cup anteversion ($^\circ$)	18.6 ± 5.4	18.5 ± 4.4	18.7 ± 9.0	0.864
Cup size (mm)	50.8 ± 4.5	51.3 ± 4.3	50.0 ± 3.9	0.146
Cup loosening at last follow-up	0	0	0	
Femoral component				
VerSys [®] Fiber Metal Taper (Zimmer)	63	58	5	0.000
Wagner SL (Zimmer)	28	1	27	0.000
VerSys [®] Beaded FullCoat (Zimmer)	5	0	5	0.000
Prosthetic femoral head size (mm)	30.9 ± 3.2	31.1 ± 3.0	30.6 ± 3.1	0.512
Stem size (mm)	12.3 ± 2.1	11.1 ± 2.3	14.1 ± 3.1	0.000
Stem fixation at last follow-up				
Bony ingrowth	78	52	26	0.223
Stable fibrous ingrowth	18	7	11	0.141
Unstable	0	0	0	
Stem subsidence	8	3	5	0.146
Stem subsidence (mm)	2.7 ± 1.0	2.3 ± 0.9	3.2 ± 1.5	0.063
Stem loosening at last follow-up	0	0	0	

Data displayed using means \pm SD or n; group I represents THAs for failed internal fixation after femoral neck fracture while group II represents THAs for failed internal fixation after femoral intertrochanteric fracture.

LLD= leg length discrepancy.

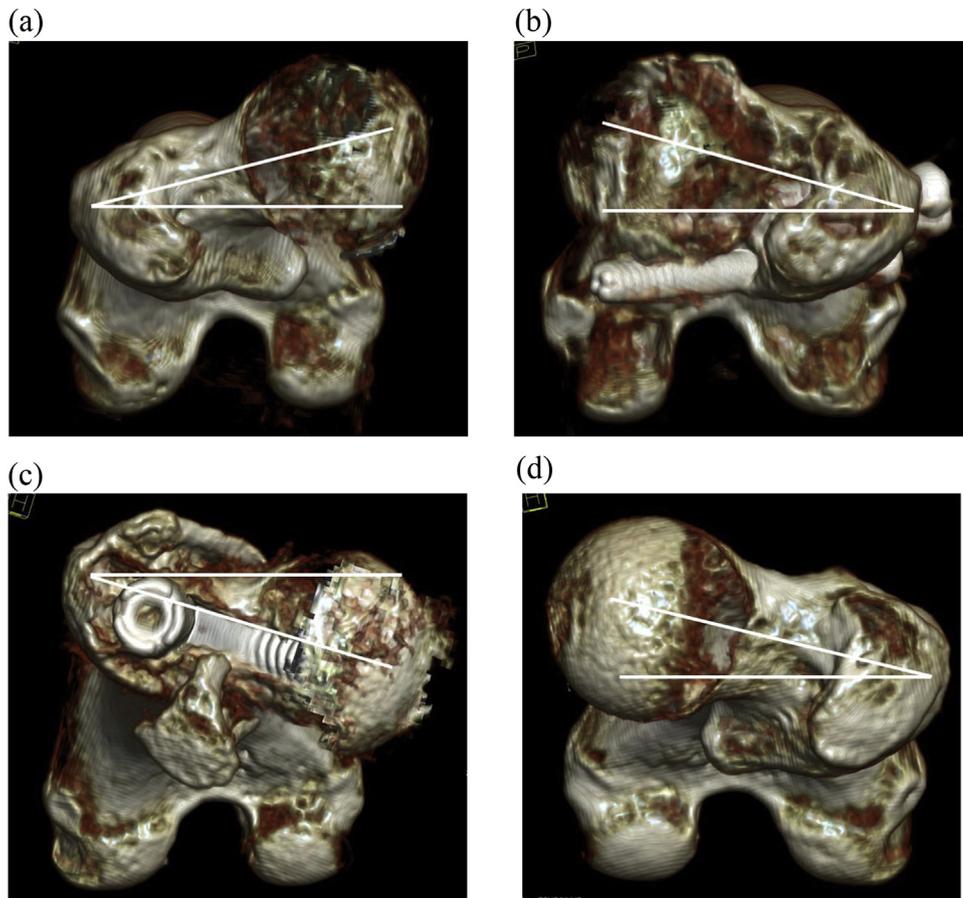


Fig. 2. The 3-dimensional reconstruction CT images show that preoperative femoral neck anteversion of the affected side is similar to that of the healthy side in a patient with failed femoral neck fracture (A and B). Preoperative femoral neck anteversion of the affected side was less than that of the healthy side in a patient with failed femoral intertrochanteric fracture (C and D).

The cause of conversion to THA in the two fractures was different. Non-union was more frequent in intertrochanteric fracture, compared to femoral head osteonecrosis in femoral neck fracture. In other words, the non-united head, neck, and trochanteric fragments are usually in a deformed position in failed internal fixation for femoral intertrochanteric fractures. In concurrence with previous studies [5,26], salvage of failed internal fixation for femoral intertrochanteric fractures was technically more challenging than that of neck fractures in our cohort, with longer operating times and higher volume of blood loss. In THA of failed internal fixation for femoral neck fractures, hardware removal can be readily performed because fractures are fixed with pins or screws. However, in THA of failed internal fixation for femoral intertrochanteric fractures, the removal of failed nails and side plates involves more extensive dissection and sometimes requires special instruments for the removal of broken screws. Bone loss distal to the usual neck cut level for hip arthroplasty is common in failed internal fixation for femoral intertrochanteric fractures. In addition, there are usually diaphyseal cortical defects related to removed hardware in intertrochanteric fractures that should be addressed intraoperatively. The decision to use a particular implant is based on the individual patient age, bone stock, and type of implant failure and it is difficult to use a single modality to treat these patients. A meta-diaphyseal mismatch is frequently seen following mal- or non-union, and standard cementless femoral stems may not be suitable. Long femoral stems are frequently required to make up for bone deficiency and restore limb length. In our series, such implants were used in 86% of patients with failed internal fixation for femoral

intertrochanteric fracture to bypass cortical defects left at the site of failed fixation devices.

The dislocation rate is reportedly higher in THAs performed because of failed internal fixation for proximal femur fracture than after primary THAs [27,28]. In this study, 7.3% of patients had a dislocation (Group I: 6.8%, Group II: 8.1%). Most femoral necks remain intact in patients with femoral neck fractures as the fracture line is more proximal. In this study, we found that after intertrochanteric fracture, femoral neck anteversion was 7.0° less than that on the healthy side. This deformed anatomy due to mal- or non-union after an intertrochanteric fracture would have a more critical influence on femoral stem alignment, and might be a risk factor for postoperative dislocation. Modular implants may have an advantage in such a situation [29]. In the current study, dislocation rate was much lower than in the published literature despite the use of non-modular cementless long stem with variable lengths and diameters for bypassing screw holes and bone defects. To avoid dislocation, it is therefore important to implant a femoral stem at the optimal alignment and angle in patients with failed internal fixation for femoral intertrochanteric fractures, although other factors such as head size or dual mobility articulation maybe associated with dislocation [30,31]. The mean postoperative LLD in failed internal fixation for femoral intertrochanteric fractures was significantly shorter than failed femoral neck fractures. The preoperative anatomical deformity of proximal femur in the intertrochanteric fractures was thought to have affected these results. Unlike our hypothesis that more complications are associated with THA after intertrochanteric fractures, there were no significant differences in perioperative complications between both groups.

This study has several limitations. First, this was a single-center retrospective cohort study. However, we account for all pre- and postoperative radiologic and clinical outcomes in our consecutive patients. Second, this study lacked consistency in terms of the type of implant used during the primary surgery. Therefore, it might be difficult to provide definite comparisons between these two fractures [32]. Thirdly, we did not classify femoral intertrochanteric fractures in detail. Intertrochanteric fractures can range from stable to highly comminuted fractures which may extend below the lesser trochanter. There were no fractures with comminuted or detached greater trochanter as we used no hook plates or other forms of fixation to attach the greater trochanter in this study. Finally, we were not able to retrieve information on the postoperative positions of the acetabular components and femoral stems using postoperative CT scans, although we attempted to place the proper position in the safe range, considering the deformed proximal femur during surgery. These limitations are obvious obstacles to the generalization of our results; thus, further multicenter prospective studies are required to verify their authenticity.

Conclusions

Outcomes of cementless THA following failed internal fixation for femoral neck and intertrochanteric fractures with 3–13 years' follow-up proved to be satisfactory. Significant pain relief and improved walking ability were observed postoperatively. Our results indicate that stable fixation of the implant can be achieved with good functional outcome in a reproducible fashion. Postoperative mal-union following failed intertrochanteric fractures could result in distorted anatomy of the proximal femur, especially with respect to femoral neck anteversion. In patients with failed internal fixation for femoral intertrochanteric fracture, cementless THA should be planned and performed, bearing in mind the increased intraoperative blood loss, operating time, and requirement of long femoral stem.

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Conflict of interest

None of the authors received payments or service, either directly or indirectly (i.e., via his institution), from a third party in support of any aspect of this work.

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